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VOLUME CXVII.

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No. 3032.—JANUARY 4, 1918.

THE SAMPLING AND ASSAY OF CHINESE TIN.

By FRANK BROWNE, F.I.C.,
formerly Government Analyst, Hongkong.

TIN is sent to Hongkong from the Yunnan mining district to be further refined in the native foundries. After purification the metal is cast into 1 cwt. ingots, stamped with the quality of the tin, namely, No. 1 or 3, together with the name of the smelter. The No. 1 quality is usually from 99·0 to 99·5 and the No. 3 from 96·0 to 96·5 per cent purity.

When tin is bought the native firm is approached for a lot of 5 to 25 or more tons. The Chinese vendor sets aside the appropriate number of ingots, tells the purchaser he may test them how he pleases, and that when the Hongkong Government has passed the tin as being of the stated quality, the metal must be paid for, and further, that after such payment no question arising from inferior quality will be considered. It was at the unanimous request of those concerned that the Hongkong Government undertook the certificating of the metal.

The Sampling.

The Government Analyst is notified by the prospective purchaser that some tin is to be examined, and samples are thereupon drawn by the former from one-tenth of the number of slabs in the lot submitted. With a twist drill these slabs are bored, top and bottom, alternately. The drilling machine is a very strong portable kind, to which a heavy steel plate has been added to form a base, the ordinary support for metal having been removed. When thus fitted the drill is placed on the ground, and the slabs carried one by one to the plate are dealt with rapidly by the driller sitting alongside. The borings are collected and taken to the laboratory for the assay. The mark H ↑ K is then punched on to every slab as a guarantee of quality and to prevent substitution. In the event of the assay showing that the tin is under the quality vouched for, the punch marks are at once removed by a Government officer.

The Fusion.

The borings are melted together under palm oil at a low temperature in an iron ladle. The resulting ingot is washed in water containing washing soda, scraped to brightness, and filed with a fine file. The melting together of the borings has been shown by analysis to eliminate no impurity. A sample of No. 3 quality melted four times as described, and assayed after each fusion, gave identical figures, and the No. 1 quality after melting has given no higher percentage of metal. Good tallow seems to answer just as well as the vegetable fat.

The Assay.

An exact quantity of 1 grm. of the filings is put into each of two flasks, each fitted with a rubber cork and a short glass tube, and the two estimations are then performed in accordance with the method of assay described by L. Parry—"The Assay of Tin and Antimony." As several thousands of these analyses have been done by the ferric chloride solution recommended by him, considerable experience has been obtained of this process. Some details may be useful to those seeking a trustworthy and rapid method for tin estimation, which has been found to be accurate to 0·1 per cent of metal. The writer can uphold every word that Parry says for the ferric chloride titration.

The hydrochloric acid employed should be of good quality, free from sulphurous acid. Any sample showing this impurity by Girardin's stannous chloride test should be rejected or set aside till free. When performed with care and attention the titrations do not require an atmosphere of carbon dioxide. Of course the standardisation of the ferric chloride solution, and the subsequent assays performed with it, must be carried out in exactly the same way. The metal used for standardising was of 99·76 per cent purity, determined by ascertaining the total of the impurities in a piece of nearly pure metal. It was found that the titration figure was the same before and after the standard had been melted under palm oil. No estimations of tin were done in any burette other than that used for valuing the ferric chloride solution. As in a hot climate the room temperature may vary between 15° and 30° C., endeavours were made always to titrate both the standard tin and ordinary samples at the same temperature. This could not always be done, but it was found that a correction at the rate of ± 0·1 cc. for 10° C. below or above the temperature at which the volumetric solution was set, gave a true reading when 50 cc. were used. The solution was marked always so as to show the final tint obtained, thus 49·64 cc. = 1 grm. 99·76 tin titrated to a pale colour.

Probably the absence of any appreciable oxidising effect by the air on the titrations was due to its being possible with these tins of fixed quality to run in almost the whole of the volumetric solution at once. The upper part of the liquid in the assay flask would thus be highly coloured, and forms a protective covering to any unattacked stannous solution below. Then on again raising the flask contents to boiling the two layers mix, and repeated experiments have shown there is not sufficient exposure to lower the true content of tin. Of course the operation from start to finish must be conducted with no unnecessary delay. When the quality of the tin submitted was found to be between 99·0 and 99·1 for the No. 1, and between 96·0 and 96·1 for the No. 3 quality, the smelter

was notified that he was running the quality too near the rejection limit of "anything under 99·0 or 98·0 respectively," and improvement invariably followed.

With the precautions mentioned, it was possible to export tin of reliable and uniform quality. Much to the satisfaction of those interested in this valuable export trade the London Metal Exchange decided that the results as found in the Hongkong Government certificate should be binding on all purchasers, thus placing the tin sales on a firm and workable basis.

Usually Chinese tin dissolves completely in hydrochloric acid, but occasionally there is a little black powder which obstinately resists attack. After investigation it was found that although the ferric chloride solution when run in dissolved everything up, the percentage of tin was not above that found when the impurity had been eliminated by the usual methods. The amount of black powder was never very large, and was mainly antimony.

Finally, possibly the most likely source of error in tin examinations is due to imperfect solution of the metal. Particularly is this the case when the filings have been placed in a water or air-oven for several hours. Superficial oxidation may then hinder the action of the hydrochloric acid, so that minute, very slowly dissolving, particles escape observation. The nascent hydrogen evolved by these vitiates the estimation.

The above description represents the Hongkong methods of tin examination in use in 1915, since when no information has been received that the processes have in any way been altered.

THE CONSTITUTION AND FUNDAMENTAL PROPERTIES OF SOLIDS AND LIQUIDS.*

PART II.—LIQUIDS.

By IRVING LANGMUIR

(Continued from vol. cxvi., p. 317).

THE iso-compounds gave practically the same results as the normal. No reason is given by Szyszkowski for the constancy of B or the changes in A. If we deal with rather concentrated solutions so that c is large compared to A then in Equation 3 we may neglect unity in comparison with c/A. Under these conditions γ is a linear function of the logarithm of c. This is the relation found for acetic acid by Milner, and according to Gibbs' equation this must mean that the amount of fatty acid adsorbed in the surface is independent of the concentration.

By differentiating (3) we obtain—

$$d\gamma = -0\cdot434\,B\gamma\frac{dc}{c+A} \quad . \quad . \quad . \quad . \quad (4).$$

Substituting this in (1) yields—

$$q = \frac{0\cdot434\,B\gamma_0}{RT}\,\frac{c}{c+A} \quad . \quad . \quad . \quad . \quad (5).$$

This equation shows us that for very dilute solutions (c small compared to A) the amount adsorbed in the surface is proportional to the concentration, and is equal to—

$$q = \frac{0\cdot434\,B\gamma_0}{RT}\,\frac{c}{A} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6).$$

The amount adsorbed increases more slowly than the concentration, and finally when c is large compared to A, the surface becomes saturated. The limiting amount adsorbed is then—

$$q_\infty = \frac{0\cdot434\,B\gamma_0}{RT} \quad . \quad . \quad . \quad . \quad . \quad . \quad (7).$$

Since B was found to be the same for different fatty acids the number of molecules adsorbed per unit area must be the same. If we multiply q_∞ by N (the Avogadro number), we obtain the number of molecules per sq. cm. The reciprocal of this gives us a_s, the area covered by each molecule when the surface is saturated. We thus find—

$$a_s = \frac{1}{Nq_\infty} = \frac{RT}{0\cdot434\,NB\gamma_0} \quad . \quad . \quad . \quad . \quad (8).$$

Taking $R = 83\cdot2\times10^6$, $N = 6\cdot06\times10^{23}$, $T = 293°$, and $\gamma_0 = 72\cdot5$,—

$$a_s = \frac{12\cdot8\times10^{-16}}{B} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9).$$

Substituting the value $B = 0\cdot411$ found by Szyszkowski we obtain $a_s = 31\times10^{-16}$ sq. cm. per molecule. This value comes reasonably close to the value $a_0 = 21\cdot5\times10^{-16}$ found for the higher fatty acids by the study of the films on water. The fact that a_s has the same value for each of the acids from propionic to caproic shows that in the more concentrated solutions the molecules in the adsorbed surface layer are packed tightly side by side with the hydrocarbon chains arranged vertically.

In the case of very dilute solutions we see from Equation 6 that the different acids are adsorbed in the surface layer in different amounts, these being inversely proportional to the values of A (Table II.). The longer the hydrocarbon chain the greater the adsorption from a dilute solution, although with more concentrated solutions the length of the chain is without influence.

These facts are readily explainable by the new theory of surface tension. Let us consider what must be the mechanism of these phenomena. In the surface of a sufficiently dilute solution the molecules of the fatty acid will be so far apart that they do not influence one another. There must be a kinetic equilibrium between the molecules arriving at the surface from the interior and those passing from the surface to the interior. The rate at which the molecules arrive at the surface is proportional to the concentration. The rate at which they pass into the interior is proportional to the number in the surface. For equilibrium in dilute solutions it is evident that the number in the surface must be proportional to the number in the interior. This explains the form of Equation 6, which merely states that q is proportional to c and serves as a definition of the constant A. From the above kinetic considerations, together with the conclusion that a saturated surface layer must consist of a layer one molecule deep, we thus obtain from Gibbs' equation a rational derivation of Szyszkowski's empirical equation.

The potential energy of a molecule of a fatty acid is lower when the molecule is on the surface than when it is in the interior. The rate at which molecules pass from the interior to the surface depends primarily on the concentration of the solution, but not on the difference of potential energy between the molecules in the interior and on the surface. The rate at which the molecules pass from the surface back to the interior depends on the number of molecules in the surface, but is also dependent to a very great degree on the difference in the potential energy of the molecule in the two states. The phenomena is quite analogous to evaporation. The manner in which m, the "rate of evaporation" of the molecules from the surface into the interior of the liquid, varies with the difference of potential energy may be calculated from Maxwell's distribution law. (For further details see Equation 5 and the references given in the footnote on page 2254 of Part I. of this paper—*Journ. Am. Chem. Soc.*, 1916, xxxviii., 2221).

Taking into account the kinetic equilibrium between the surface layer and the interior of the solution it may be readily shown that the following relation should hold between the amount adsorbed in the surface and the concentration in the solution—

$$\frac{q}{c} = K\epsilon^{\lambda/RT} \quad . \quad . \quad . \quad . \quad (10).$$

Here λ is the decrease in potential energy which occurs when a grm. molecule of the dissolved substance pass

* From the *Journal of the American Chemical Society* xxxix., No. 9.

from the interior of the solution into the surface layer. K is a constant.

We may now apply this equation to the case of a series of solutions of homologous compounds. If λ increases in arithmetical proportion as we pass from one member of the series to the next, then according to (10) the ratio q/c will increase in geometrical proportion. By Equation 6, q/c is inversely proportional to A, the constant tabulated in Table II. Combining Equations 6 and 10 we obtain for any two members of a homologous series—

$$\frac{A}{A'} = e^{\lambda' - \lambda/RT} \quad . \quad . \quad . \quad . \quad . \quad (11).$$

Now the experimental data of Table II. show that A decreases in a constant ratio each time a CH_2 group is added to the hydrocarbon chain. Taking this ratio to be 3·4, and substituting in Equation 11 gives $\lambda' - \lambda = 2{\cdot}98 \times 10^{10}$ ergs. per grm. molecule, or 710 grms. calories per mol. We may thus conclude from the experimental data that each CH_2 added to the hydrocarbon chain of a fatty acid increases the potential energy λ in very dilute solutions by the constant amount of 710 calories per grm. molecule. This must mean that each CH_2 added occupies a similar position, in regard to the structure of the surface layer, as the CH_2 groups already present. Since the range of the forces involved is small compared to the size of the molecules, it must therefore follow that each CH_2 group in these dilute solutions forms a part of the surface. In other words, the hydrocarbon chain lies spread out flat on the surface of the water. As the concentration of the solution increases the molecules become more closely packed in the surface layer, and finally when the surface becomes saturated the molecules are all arranged with their hydrocarbon chains placed vertically.

We have seen in the case of the higher fatty acids that the surface films have no appreciable effect on the surface tension until their molecules are packed tightly. With the saturated fatty acids they must even be packed so that they stand vertically on the surface before affecting the surface tension. The lower fatty acids on the other hand change the surface tension considerably even when the number of molecules on the surface is very much less than enough to cover the surface with a single layer.

We have seen in the derivation of Equation 6 that for dilute solutions of fatty acids q is proportional to c. From Equation 1 this means that $d\gamma/dc$ is constant, or in other words γ is a linear function of c. We may therefore place—

$$-\frac{d\gamma}{dc} = \frac{F}{c} \quad . \quad . \quad . \quad . \quad . \quad . \quad (12).$$

where—

$$F = \gamma_0 - \gamma \quad . \quad . \quad . \quad . \quad . \quad . \quad (13).$$

The number of molecules adsorbed in the surface is Nq, so the area per molecule is—

$$a = \frac{1}{Nq} \quad . \quad . \quad . \quad . \quad . \quad (14).$$

Substituting (12) and (14) in (1) we find—

$$F \, . \, Na = RT \quad . \quad . \quad . \quad . \quad . \quad (15).$$

This equation is exactly analogous to the gas law $pV = RT$. The quantity Na is the area available per grm. molecule, and correspond to V. The force F is the force with which the film tends to spread over the surface, and this corresponds to the gas pressure p.

With dilute solutions of the lower fatty acids the adsorbed films thus follow the laws of ideal gases. From the kinetic viewpoint this means that the molecules are free to diffuse over the surface and are taking part in the thermal agitation (Brownian movement) just as any gas molecule does. The strips of paper on the surface of the water in the apparatus shown in Fig. 6 correspond to semipermeable membranes, which allow the water to pass, but not the substance in the surface film.

The magnitude of the forces due to this gas-like expansion of surface film is by no means small. Thus from Equation 15 we calculate that at 20° the force F would be 4 dynes per cm. when $a = 100 \times 10^{-16}$ sq. cm. per molecule.

From Fig. 8 we see that in the case of the higher fatty acids the films do not spread upon the surface in the way required by Equation 15. Thus with palmitic acid the force F falls to less than 0·2 dyne per cm., when $a = 23 \times 10^{-16}$ sq. cm., whereas by (15) the force should be 17·5 dynes per cm. for this value of a. (To measure the relation between a and F for very small values of F a special balance like that of Fig. 6 but of greater sensitiveness was constructed. By also using a weaker air blast it was possible to increase the sensitiveness many fold, so that a force of 0·05 dyne per cm. could be measured with certainty. Until the force F decreases to about 0·4 dyne per cm. or less the curve shown in Figs. 8—18 approach the horizontal axis, forming a definite angle with it, instead of approaching it asymptotically. For still weaker forces (0·05 to 0·3 dyne per cm.) a transition curve asymptotic to the horizontal axis was sometimes observed, but this appeared to be due to some contamination of the water surface rather than to the substances investigated).

This means that the film no longer behaves like a gas, but rather as a liquid or solid. Adsorbed films in the surfaces of liquids may thus exist in three distinct conditions corresponding to the solid, liquid, and gaseous states. It is to be expected that the transition from gaeous to liquid films may be either continuous (as in the case of the lower fatty acids), or discontinuous (higher fatty acids), and that under proper conditions, phenomena quite analogous to the critical phenomena of gases should be observed.

Any solid or liquid film must have a certain tendency to spread on the surface by giving off separate molecules which will follow the gas laws. This tendency may be measured as a "surface-vapour-pressure." With palmitic acid and higher fatty acids this pressure is less than 0·1 dyne per cm. The smallness of this pressure for the higher fatty acids must be due to attractive forces between the molecules powerful enough to prevent their separation. These same forces tend to prevent the film from evaporating from the surface into the vapour phase and from going into solution in the water. There are thus intimate relationships between the lowering of surface tension produced by fatty acids and the vapour pressures and solubilities of these substances. These relationships will be discussed in more detail in another part of this paper.

When the solubility or vapour pressure of a surface film is not negligible the paper strips of the apparatus shown in Fig. 6 are no longer equivalent to semipermeable membranes, so that this method fails. It will probably be possible by means of Gibbs' Equation 1 or a more accurate equation of similar type, to study the relations between F and a during the transition from the state of liquid films to that of "gaseous" films.

Before discussing in more detail the mechanism of adsorption in the surfaces of liquids, let us consider some additional experimental data on the surface tension of solutions.

The surface tensions (at 15°) of a large number of aqueous solutions of organic substances have been accurately determined by J. Traube (*Ann.*, 1891, cclxv., 27—55). His results are given in a form which renders them particularly adapted to our present purposes. In each case he measured the surface tensions of solutions of the following concentrations:—1, 0·5, 0·25, 0·125, &c. grm. molecules per litre. He continued diluting each solution until the surface tension became nearly equal to that of pure water. In some cases it was necessary to dilute to 1/1024 mols. per litre. Traube drew the following general conclusions from his work on organic substances containing hydrocarbon chains with a single active group (acids, alcohols, esters, amines, and aldehydes)—

1. For very dilute solutions the depression of the surface tension, $\gamma_0 - \gamma$ (or F) is proportional to the concentration In other words F/c is constant.

TABLE III.

Substance	Range of V	$(F/c)_0$	B.	$\lambda_{obs.}$	$\lambda_{cal.}$	$\sigma_S \times 10^{-1}$ sq. cm.
Formic acid, $HCOOH$	1—8	8·0	—	1078	1062	—
Acetic acid, CH_3COOH	1—16	27·0	—	1710	1687	—
Propionic acid, C_2H_5COOH	1—64	77·0	0·37	2290	2312	33·8
Butyric acid, C_3H_7COOH	1—128	230·0	0·40	2910	2937	31·2
Iso-butyric acid, C_3H_7COOH	1—128	240·0	0·40	2940	2937	31·2
Iso-valeric acid, C_4H_9COOH	4—256	720·0	0·41	3570	3562	30·5
Methyl alcohol, CH_3OH	1—8	11·0	—	1240	1200	—
Ethyl alcohol, C_2H_5OH	1—16	33·0	0·39	1820	1825	32·0
Propyl alcohol, C_3H_7OH	1—32	98·0	0.43	2430	2450	29·1
Iso propyl alcohol, C_3H_7OH	1—32	98·0	0·36	2430	2450	34·7
Iso butyl alcohol, C_4H_9OH	1—64	310·0	0·45	3080	3075	27·8
Iso-amyl alcohol, $C_5H_{11}OH$	4—128	910·0	0·45	3700	3700	27·8
Methylacetate, CH_3COOCH_3	1—32	85·0	0·42	2340	2345	29·8
Propyl formate, $HCOOC_3H_7$	1—128	250·0	—	2960	2970	—
Ethyl acetate, $CH_3COOC_2H_5$	2—128	270·0	0·42	3000	2970	29·8
Methyl propionate, $C_2H_5COOCH_3$	2—128	245·0	0·44	2950	2970	28·4
Propyl acetate, $CH_3COOC_3H_7$	8—256	840·0	>0·41	3650	3595	30·5
Ethyl propionate, $C_2H_5COOC_2H_5$	8—256	745·0	>0·41	3580	3595	30·5
Propyl propionate, $C_2H_5COOC_3H_7$	32—1024	2050·0	>0.37	4160	4220	33·8
Allyl acetate, $CH_3COOC_3H_5$	8—256	470·0	>0·42	3320	3195	29·8
Allyl alcohol, C_3H_5OH	1—32	46·0	0·44	2000	2050	28·4
Allyl amine, $C_3H_5NH_2$	1—32	51·0	0·31	2060	2075	38·4
Propylamine, $C_3H_7NH_2$	1—32	110·0	0·35	2490	2475	34·0
Butyl aldehyde, C_3H_7CHO	2—64	160·0	0·48	2710	2710	24·8
Oxy-butyric acid, $C_3H_6(OH)COOH$	2—32	53·0	0·25	2080	2137	47·7
Acetone, $CH_3CO.CH_3$	1—32	62·0	0·28	2170	2170	42·5
Dimethyl-ethyl carbinol, $(CH_3)_2(C_2H_5)OH$	2—256	590·0	0·33	3450	3450	36·1
Paraldehyde, $C_6H_{12}O_3$	2—64	240·0	0·42	2940	—	28·4
Glycol, $(CH_2OH)_2$	1—8	2·4	—	563	550	—
Acetamide, CH_3CONH_2	1—8	3·8	—	740	740	—
Oxalic acid, $(COOH)_2$	4—8	2·1	—	516	550	—
Methyl oxalate, $(COOCH_3)_2$	4—32	36·0	—	1870	1800	—
Malonic acid, $CO_2H.CH_2.CO_2H$	4—8	12·0	—	1280	1175	—
Succinic acid, $CO_2H.CH_2.CH_2.CO_2H$	4—8	18·5	—	1510	1800	—
Maleic acid, $CO_2HCH:CHCO_2H$	4—32	8·3		1090	1400	—
Fumaric acid, $CO_2H.CH:CH.CO_2H$	32	11·5	—	1260	1400	—
Malic acid, $CO_2H.CH_2.CHOH.CO_2H$	4—8	6·0	—	940	1000	—
Tartaric acid, $CO_2H(CHOH)_2CO_2H$	1—8	0·5	—	172	200	—

2. The ratio F/c for dilute solutions increases about threefold for each CH_2 added to the hydrocarbon chain in the molecules.

3. As the concentration of the solution increases F ceases to be proportional to c, but increases more slowly than c.

4. The concentration at which F ceases to be proportional to c is lower the greater the length of the hydrocarbon chain.

5. At still higher concentrations F increases by constant increments (about 8·0 dynes per cm.), each time the concentration is doubled. That is, the surface tension decreases in arithmetical proportion while the concentration increases in geometrical proportion.

6. The depression of the surface tension F is expressed as a function of the concentration c by the following equation:—

$$F = f\,(c/A) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16).$$

Here A is a constant characteristic of each substance and f represents a function which is the same for all substances.

Traube explained the first of the above conclusions by kinetic considerations much as has been done in this paper. He either did not attempt to explain the other relations or he gave explanations which at present are of little value.

It is interesting to note that in the above conclusions Traube anticipates by sixteen or seventeen years most of the relations found by Milner and by Szyszkowski. The present theory of the structure of the surface layer furnishes a rational explanation of each of Traube's conclusions.

Traube's results can be expressed fairly well by Szyszkowski's Equation 3. This equation may be written in the form—

$$F = B\gamma_0 \log\left(1 + \frac{c}{A}\right) \quad . \quad . \quad . \quad . \quad . \quad (17).$$

For very dilute solutions, where c/A becomes small compared to unity the ratio F/c becomes constant and equal to—

$$\left(\frac{F}{c}\right)_0 = \frac{0{\cdot}434\ B\gamma_0}{A} \quad . \quad . \quad . \quad . \quad (18).$$

On the other hand for concentrated solutions where c/A is large compared to unity, Equation 17 reduces to—

$$F = B\gamma_0 \log c - \text{constant.} \quad . \quad . \quad . \quad (19)$$

Traube usually started with a grm.-molecular solution repeatedly doubling its volume so that the molecular volume V was increased through the steps 1, 2, 4, 8, 16, &c. The value of F at first decreased by more or less constant increments—ΔF. But as the solution became more dilute ΔF became approximately proportional to c as would be expected by Equation 18. For concentrated solutions where Equation 19 still holds, we thus obtain—

$$\Delta F = B\gamma_0 \log 2. \quad . \quad . \quad . \quad . \quad . \quad . \quad (20).$$

Substituting $\gamma_0 = 72{\cdot}95$, we get—

$$B = 0{\cdot}0454\ \Delta F. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21).$$

In attempting to calculate B from Traube's data it was found that the range of concentration was usually not quite sufficient to allow Equation 21 to be applied with accuracy.

The equation actually used in calculating B was obtained by expanding (17) into a series and combining the result with (18) and (21) as follows:—

$$B = 0{\cdot}0454\ \Delta F \left(1 + \frac{\Delta F}{(cF/c)_0}\right) \quad . \quad . \quad . \quad (22).$$

The correction term in the second member usually amounts to less than 10 per cent.

Similarly it was found that the values F/c given by Traube did not quite reach a constant value as the solutions were diluted. An extrapolation formula based on an expansion of (17) was also developed for this case—

$$\left(\frac{F}{c}\right)_0 = \frac{F}{c}\left(1 + \frac{F}{63B}\right) \quad . \quad . \quad . \quad (23).$$

Here B was first calculated by (22).

Table III. contains values of B and $(F/c)_0$ calculated for a large number of substances from Traube's data. The first column gives the range in the molecular volumes V of the solutions used by Traube. The second gives values of $(F/c)_0$ calculated by Equation 23. The next column gives values of B by (22). In some cases the maximum concentration used by Traube was not sufficient to yield a saturated surface. This was shown by a marked lack of constancy in the values of ΔF for the higher concentrations. In such cases the value of B could not be determined, or at most only a lower limit for B could be found.

(To be continued).

THE NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES, HELD IN NEW YORK.*

By THOMAS H. NORTON, Ph.D., Sc.D.

Wholly apart from its appeal to the eye, but of vastly greater importance, was the undercurrent of intense seriousness which sooner or later inevitably forced itself upon visitors to the National Exposition of Chemical Industries held in New York. In the following analysis of the event, the writer interprets its psychological as well as its commercial significance, and also gives a thorough review of the exhibits and addresses.

The Third National Exposition of Our Country's Chemical Industries, held on the week beginning September 24, at the Grand Central Palace in New York City, was in every way a notable event.

The first exposition, in September, 1915, was largely tentative, but proved to be a distinct success. When its successor was held in 1916 the number of exhibits was doubled and the attendance largely increased.

In 1917, despite the fact that we are fairly embarked upon a war, prospectively the greatest in our national history, the exposition proved to be a pronounced advance upon that of the preceding year. The exhibitors numbered 325, and the space occupied was triple that of 1915, three floors of the vast building being covered by their displays.

The number of admissions was over 100,000. It was estimated that about 25,000 chemists, consumers of chemicals, producers of chemicals, and manufacturers of the accessories required by the latter were brought together by the exposition.

It was eminently educative, although practical business purposes were the chief incentive in the case of most exhibitors. As a rule, what they displayed in their booths was so arranged and labelled or explained by competent attendants that the layman could easily grasp the economic importance of the wares shown. Their origin, their relation to one another, their uses were all brought out clearly, and in most instances attractively and tastefully.

There was, however, an almost complete absence of the spectacular. An undertone of great seriousness was evident. Not only the topics of conversation among the throngs in attendance, but the character of the exhibits and the dominating note in the various addresses and lectures all revealed a consciousness that we have entered upon an historical epoch destined to test to the uttermost the entire fabric of American chemistry as well as American ingenuity, adaptation, and inventive skill.

There was an inspiring conviction that the chemists of our nation are fully competent to deal with the manifold problems accompanying this greatest of the world's wars, in which we are now about to play a leading part, possibly the decisive *rôle*. It is pre-eminently a war of engineers and chemists. Can American chemists show themselves fully equal to the chemists of Europe in evolving methods of offence and means of defence?

The booths of the exposition contained the answer. They revealed to the eye the wonderful accomplishments of the past three years. They showed how swiftly and how effectively it has been possible to create on American soil the manufacture of a multitude of products, for which a few months ago we were entirely dependent upon European sources. The eye rested frequently upon the imposing mechanical appliances requisite for the life of new-born chemical industries.

Leaders of American chemistry pourtrayed eloquently how we have become a giant purveyor of powerful explosives; how we are dealing with a multitude of problems intimately associated with war in the air and beneath the ocean's waves as well as in the trenches.

The intelligent and patriotic citizen could not leave the halls of the exposition without the profound conviction that our chemists form a first line of national defence, that without their whole-hearted far-reaching co-operation the power of the legions we send across the Atlantic would be sadly crippled.

In analysing the exposition more in detail there was general recognition of the leading *rôle* played by the coal-tar chemical industry. Its products were shown in abundance upon every hand. They lend themselves admirably to effective displays for the eye, and they revealed in a concrete form the marvellous creation during a few months of what will constitute permanent factors in our economic structure.

Next in interest came the varied mechanical devices provided for the chemist to accomplish his wonders. There is little doubt but that the confidence and assurance felt by our chemists in facing the numerous problems of to-day and of the morrow is vastly reinforced by the realisation of the equal ability of our engineers to furnish the most varied equipment for their needs.

Closely associated in this connection was the evidence of the success recently following American enterprise in making from American materials the many diverse articles in glass and porcelain needed constantly by the chemist, but obtainable hitherto only from Germany. In this category falls also the fine quality of optical glass now made in the United States.

All in all the exposition was thoroughly worthy of the nation's swiftly expanding industry, in which so many millions have been invested these past three years. It was eminently satisfactory to the economist, revealing the degree to which we are emancipating ourselves from foreign dependence. Finally, it was inspiring to the intelligent and patriotic citizen, outlining clearly one of the potent factors for success in the war before us.

The Exhibits.

It is impossible to present more than a very cursory mention of the many exhibits of distinct value to those interested in coal-tar chemistry.

To a certain extent something of value, something suggestive and helpful, might be found in nearly every display. This was especially true of the many exhibits of machinery and other accessories required in chemical plants.

* From the *Chemical Engineer*, October, 1917.

It seems, however, desirable to group together those exhibits which revealed in a very striking manner the present status of coal tar chemistry in the arts, and the tremendous advance made during the past two or three years. Enough detail is furnished in connection with the name of each company exhibiting to give a fair idea of the extent and variety of its operations. The list includes all exhibitors engaged in the production of coal-tar crudes, in the refining of the crude products, in the transformation of such crudes into intermediates, and in the manufacture from such intermediates of finished dye-stuffs, medicinals, and other allied substances. It includes, further, the exhibits of natural dyes and of the leading firms supplying the special mechanical equipment of the plants devoted to coal-tar chemicals.

In their entirety these exhibits formed the most striking feature of the exposition and attracted general attention.

The Barrett Co., New York.

The exhibit of this company was one of the most attractive and instructive in the whole exposition, showing the great range and variety of the current commercial products isolated from coal-tar. The list of these crude and refined substances is given in full in order to convey an adequate idea of the extent to which differentiation has been carried in the primary stage of the coal-tar chemical industry for the purpose of meeting a multitude of well-defined economic needs:—Benzol, pure; benzol, 100 per cent; benzol, 90 per cent; benzol, 50 per cent; benzol, straw colour; toluol, pure; toluol, commercial; toluol, straw colour; xylol, pure; xylol, commercial; solvent naphtha; crude solvent naphtha; hi-flash naphtha; crude heavy solvent naphtha; No. 10 naphtha; heavy naphtha; pyridine, denaturing; pyridine, commercial; heavy solvent oil; shingle stain oil; special heavy oil; special heavy oil, grade 2, neutral hydrocarbon oil; creosote oil; crude carbolic acid, in 8 grades; dip oil; phenol, U.S.P., natural; phenol, U.S.P., synthetic, cresol, U.S.P.; refined cresylic acid, No. 5; ortho cresol; para-cresol; meta cresol; xylenol; naphthalene, flake, small balls, large balls, crushed, powdered, granulated, rice, lump, one ounce cakes, square tablets, and round tablets, cryst alba; anthracene (crude), 25 per cent; anthracene, 40 per cent; anthracene, 80 per cent; carbazole; phenanthrene, pyxol; tarola, X; special cresol compound; disinfecting powder; disinfectants, coefficients 2 to 20.

Quite recently the company has taken up the manufacture of various intermediates and medicinal compounds. The exhibits in this field were:—

Paracumaron resin, para-amido-phenol; nitro-naphthalene; alpha-naphthylamine; resorcin, technical; resorcinol, U.S.P.; salicylic acid, U.S.P.; sodium salicylate, U.S.P.; methyl salicylate, U.S.P.; salol, U.S.P.; salicylimide.

In the 30 different plants of the company over 200 distinct chemical products are now currently manufactured. Great quantities of benzene and toluene are furnished under contract to the Allied governments to use in making munitions.

The Barrett Company has been the chief organisation in this country to perfect the methods of separating the different constituents of coal-tar, and to popularise the use of the varied products in almost numberless directions. It is to the efforts of this company, extending back for years, that our synthetic chemists found it possible since 1914 to secure promptly large amounts of coal-tar crudes, refined to the requisite state of purity, as they laid the foundation for an American dye-stuff industry, and for the production of numerous medicinals. Synthetic phenol was made by the Barrett Company some ten years ago, although no effort was then attempted to place it regularly upon the market.

An impressive feature of the exhibit was a large wall chart showing the genealogical derivation of the leading products resulting from the destructive distillation of coal. Samples of these products, in vials of uniform size, accompanied the various names on the chart, which numbered slightly over 200. The realistic diagram is of pronounced educational value, and could most helpfully be employed in every school of science specialising in coal-tar chemistry.

The American Coal and By products Coke Co., Chicago.

This company had an interesting exhibit of the plans and materials used in the construction of the Roberts flueless coke-oven. The importance of this oven, as permitting a vastly enlarged utilisation of numerous deposits of bituminous coal, hitherto regarded as valueless for coking purposes, has attracted widespread attention. As the only by-product coke-oven of purely American origin it promises to solve urgent problems connected with the satisfactory and economic distillation of many forms of soft coal, now untouched for this purpose, and also of the enormous deposits of lignite in our Western States. The company displayed a tasteful array of coal-tar crudes and their derivatives coming from the plant at Canal Dover, O.

The H. Coppers Co., Pittsburgh, Pa.

An instructive exhibit was made of the details of construction of the coke-ovens installed by this company at various points, and contributing largely to our current supply of coal-tar crudes. The immediate products of coking were shown in a well arranged set of samples.

The United Gas Improvement Co., Philadelphia.

An extensive series of refined coal-tar crudes was shown by this company, which manufactures on a large scale all of the products obtained directly from tar. The pure compounds included benzene, toluene, xylene, and naphthalene. The manufacture from the latter of phthalic anhydride has recently been installed, and a daily production of 200 lbs. has been attained. Other exhibits were crude phenol, solvent naphthas, heavy naphthas, dead oil, creosote oil, paving and roofing pitches, road compounds, &c.

The Semet-Solvay Co., Syracuse, N.Y.

One of the most attractive features of the exposition was the finely arranged display of the company's products obtained from coal-tar. These included the hydrocarbons and the high explosives picric acid and trinitro-toluene derived from them; phenol and such derivatives as salicylic acid, methyl salicylate, acetylsalicylic acid, &c. The relationship of the various compounds to coal was shown on several tables holding sample bottle with arrows indicating the different changes as the result of chemical change. The whole exhibit was unusually instructive, and illustrated the growing tendency among manufacturers to present the basic facts in their processes so clearly and simply that they may easily be grasped by the non-scientific mind.

This organisation has contributed much to the rapid expansion of the coal-tar chemical industry by its intelligent handling of the crude material controlled by it in large amounts in connection with the establishment of Semet-Solvay by-product coke ovens. The company now operates twenty-one plants under its system, and claims to be the largest individual producer in the world of coal distillation products. It has not attempted to manufacture a great variety of compounds, but a limited number have been produced upon a very extensive scale. Sulphur black is the only dye-stuff which the company has manufactured.

The National Aniline and Chemical Co., Inc., New York.

The exhibit of this company attracted general attention from the fact that it is the largest single factor in the American coal-tar colour industry. It represents a consolidation of various interests, producers of coal-tar crudes, of intermediates, of synthetic colours, and of the chemicals required in the various stages of manufacture, which will enable it to develop along numerous special

lines at a minimum of cost of production. A few months ago it was organised by the merging together of the following companies:—Schoellkopf Aniline and Chemical Works, Inc., Buffalo; W. Beckers Aniline and Chemical Works, Inc., Brooklyn; National Aniline and Chemical Co., New York; Benzol Products Co., Marcus Hook, Pa.; Standard Aniline Products, Inc., Wappingers' Falls, N.Y.; and also certain plants and properties of the General Chemical Co., the Barrett Co., and the Semet-Solvay Co.

The extensive exhibit included a number of different categories, and covered nearly the whole range of coal-tar products. They are given in detail, as illustrating in a striking degree the wide diversity of output of our leading producer of artificial dyes and its lack of dependence upon outside sources for the materials employed.

Coal-tar chemicals, used in textile or other industries:—Aniline oil, aniline salt, β-naphthol, cresol, phenol, diphenylamine, dimethyl-aniline, hydroquinone, meta-phenylene diamine, meta-toluylene diamine, naphthylene, nitro-benzene, paranitraniline, paramidophenol, para phenylene diamine, phenol, phenyl ethyl alcohol, resorcin, sodium benzoate, thiocarbaniline, thiocarbtoluide, thiocarbxylide, benzaldehyde, benzyl acetate, benzyl benzoate, benzoic acid.

Intermediates, used chiefly in making synthetic dyes.—Amido-salicylic acid, benzidine, chromotropic acid, dinitro-benzene, dinitro-toluene, G salt, H acid, Koch acid, metanilic acid, N W acid, naphthol-1-sulphonic acid (1 : 5), ortho-toluidide, phenyl-hydrazine-sulphonic acid, paramido-acetaniline, phenyl acid, picramic acid, pseudo-cumidine, R salt, sulphanilic acid, Schaeffer salt, xylidine.

Direct aniline colours, for cotton, union goods, &c.:—Erie Black GXOO, Niagara blue 2B, Niagara dark blue 3R, Niagara blue D B, ammaco direct blue 3B, Erie brown C, Erie brown G R, direct brown T, Erie green W T, ammaco direct green W B, Erie green M T, Erie orange 2R, benzo purpurine 4B W, Congo red 4B, Niagara garnet R, ammaco primuline W B, Niagara violet B W, Niagara fast yellow F, Niagara yellow K M, ammaco chloramine yellow W B, ammaco delta red 2B.

Sulphur colours, for cotton, fast to washing, cross-dyeing, &c.:—Sulphur black F conc paste, sulphur black sap powder, sulphur blue paste, sulphur blue sap, sulphur direct navy blue, sulphur brown 2G, sulphur brown sap, sulphur brown W F, sulphur brown L Y conc, sulphur green sap, sulphur yellow B W, sulphur khaki, all shades.

Acid colours, for wool, silk, leather, lake making, &c.:—Buffalo black, N B R, Buff lo black 10B, Buffalo black 8B, Buffalo black 3G, Buffalo black R B, ammaco acid black T R, Buffalo black A R, acid black 4A B, Buffalo fast blue R, Buffalo cyanone 3R, induline, resorcin brown, fast brown, ammaco acid green L, orange A conc, orange S conc, orange 2G crystals, brilliant scarlet 3R, xylidine scarlet, fast red S conc, scarlet B R, azo rubine extra, Buffalo fast crimson R, azo Bordeaux, Buffalo fast fuchsine D, Buffalo fast fuchsine G, Buffalo fast fuchsine R, Buffalo fast fuchsine 6B, wool red 40F, cloth red G, cloth red R, croceine scarlet moo, lanacyl violet M, acid violet, Buffalo violet 4B, Buffalo fast violet B, wool yellow ex conc, azo yellow A 5W, metanil yellow 1955.

Basic colours, for leather, paper, lake making, cotton printing, &c.:—Brush blacks, methylene blue B S conc, ammaco basic navy blue D A conc, Bismarck brown Y ex, Bismarck brown 53, ammaco Victoria green W B, chrysoidine Y ex, chrysoidine 3R, safranine A, ammaco safranine B L, methyl violet.

Chrome colours, for wool, fast to light, fulling, &c.:—Buffalo chrome black 2B N, ammaco chrome black, B N, alizarol black 3G, alizarine blue G, alizarine dark blue G N, alizarine dark blue R B N, alizarine bright blue 3R Y N, serichrome blue R, alizarol brown B, alizarol brown R B, serichrome green B, Buffalo chrome green C B, ammaco alizarine orange W B, ammaco alizarine yellow 351, alizarol yellow 3G.

Certified colours, for food products, confectionery, &c.:—Amaranth 107, ponceau 3R 56, orange I 85, tartrazine 94, sodium indigo, disulphonate 692, Ceylon red, Sultan red, Burmah red, Coralline red, Rajah red, raspberry red, strawberry red, Brazil brown, Caracas brown, Maracaibo brown, deep chocolate, yellow colour, egg shade; Tokio orange, Tangier orange.

Miscellaneous colours, Nigrosines, water and spirit soluble:—Oil black, chrysoidine base, Victoria green, base, oil colours, fur black, fur brown.

Most of the colours were accompanied by handsome specimens of their uses on different textiles, leather, &c.

The company has branch agencies in twelve cities, and is steadily increasing the number of its tinctorial products. It is in an admirable position to present a bold face to foreign competition when the time arrives in the early future.

It is not easy for the layman, or even for the average chemist, to realise adequately the full extent to which our textile and many allied industries are indebted to the above organisation and its component parts for diminishing by wonderful energy and skilful utilisation of available materials the pinch of our dye-stuff famine.

The Central Dye-stuff and Chemical Co., Newark, N.J.

This company has been an important factor in laying the foundation of the American artificial colour industry, its origin dating back to 1898. It has specialised in azo dyes, and its products have been of great value in meeting the pressing demands of the past three years. The current output was displayed in a most attractive manner, and included the following colours:—Fast red, orange G and Y, erythrine, benzopurpurine B, naphthol blue, scarlet 2R, methyl violet 3B, chrysoidine X, diamine blue 2B, azo rubine, claret red R B, Bismarck brown R and Y, amaranth, chrome black, fast acid red 6B G, amido black B, wool orange G, wool scarlet 4R, Bordeaux, lake violet, lake scarlet, lake brown, lake orange, roccelline, methylene blue, wool claret, induline, various nigrosines, and numerous oil colours. The company is one of the leading producers of β-naphthol and exhibited this compound, as well as α-naphthol and α-naphthylamine. Sample dyeings of all the colours were present in abundance, and the entire display gave admirable evidence of the energetic manner in which the older coal-tar colour firms are extending the range of their operations.

Consolidated Colour and Chemical Co., Newark, N.J.

This company manufactured a few colours on a relatively small scale before the war. It has not increased greatly the variety of its output, but is producing very large quantities. It displayed methylene blue, methyl-orange, chromotrope, alizarine brown, acid yellow, cotton yellow, chrome black, chrome blue, chrome yellow, Victoria leather oil, and a variety of sulphur dyes. Sample dyeings accompanied each colour.

Marden, Orth, and Hastings Corporation, New York.

This firm had a very tastefully arranged display of the products made in its seven factories, which included a large number of general chemicals, especially such as are required by dyers and tanners. The firm has branched out extensively into coal-tar products, and showed the following:—

Coal-tar Crudes and Intermediates.—Aniline oil, aniline salt, benzidine base, benzidine sulphate, benzol, β-naphthol, chlor-benzol, dichlor-benzol, dimethylaniline, dinitro-naphthyline, dinitrophenol, hydroquinone, naphthalene, naphthionic acid, nitro-benzol, nitro-toluol, paranitraniline, phenol, picric acid, salicylic acid, salol, sulphanilic acid, toluidine mixture, toluol, xylidine, ortho-toluidine, para-toluidine, sodium naphthionate, sodium salicylate sodium sulphanilate.

Acid Colours.—Acid black, acid blue, acid green, acid red, fast; croceine scarlet, orange No. 2, metanil yellow, acid yellow, azo orange.

Basic Colours.—Bismarck brown Y, chrysoidine Y, malachite green, methylene blue, methyl violet, nigrosine blue (water and spirit soluble), nigrosine jet (water and spirit soluble), Victoria blue S.

Chrome Colours,—Alizarin yellow R W, khaki No. 1 (for wool), anthracene acid brown G.

Direct Colours.—Direct black, Congo red, chrysamine G, direct blue, benzo brown G, benzo orange R.

Sulphur Colours.—Sulphur black, sulphur brown, sulphur yellow, sulphur blue, sulphur olive green.

Oil Soluble Colours.—Oil black, oil blue, oil brown, oil green, oil jet, oil orange, oil red III., oil red IV., oil scarlet, oil yellow, oil yellow D, oil yellow T.

The extraction of vegetable dyes is one of the company's specialities, and it introduced into general use aurantine paste and powder, obtained from our domestic osage orange. It exhibited the following.

Dyewood Extracts.—Logwood chips, logwood extract, hematine paste, hematine powder, hematine crystals, aurantine paste, aurantine powder, cutch, fustic extract, quercitron extract, sumac extract, cutch extract, hypernic extract, khaki No. 2 (for cotton).

The numerous samples, illustrating the use of the above colours, were grouped very effectively.

(To be continued).

PYRITES MINED IN THE UNITED KINGDOM.

PURCHASE BY THE MINISTRY OF MUNITIONS.

It is officially announced that the Ministry of Munitions is prepared during the period of hostilities to purchase iron pyrites mined in the United Kingdom.

The pyrites must contain not less than 37½ per cent of sulphur and not over 1 per cent of arsenic. The price payable will be 35*s.* per ton of pyrites f.o.r. for quentities of not less than one truck load; but the Minister reserves the right to revise the price after 31st December, 1918, or if over 5000 tons are delivered from one deposit before that date the price may be revised in respect of further deliveries from such deposit forthwith.

In the first instance samples of all ore tendered will be selected by the local agent of the Ministry, and if, upon analysis, the ore proves suitable, payment of 75 per cent of the amount of the purchase price for each consignment will be made on receipt of the railway company's certificate that the pyrites has been put on rail. The balance will be paid within sixteen days of the receipt of correct accounts.

Producers can obtain detailed particulars on application to the Department of Explosives Supplies, Storey's Gate, Westminster, S.W. 1.

Food Production.—The weekly pamphlets issued by the Food Production Department of the Board of Trade give practical and up-to-date information on questions of stock feeding, crop growing, seed testing, &c. Special attention is paid to the work of the tractors, and most satisfactory reports of progress are made. Notes are frequently given dealing with the work of women on the land to which the most enthusiastic praise is accorded, and the pamphlets will be of considerable value to farmers and allotment holders. The information will occasionally be found of interest to the public, as, for example, the details of the price, &c., of fruit and vegetable preserving jars, which should be secured in good time so that none of next season's crops may be wasted.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, December 13, 1917.

Sir J. J. THOMSON, O.M., President, in the Chair.

PAPERS were read as follows:—

"*Formation of Nitrites from Nitrates in Aqueous Solution by the Action of Sunlight and the Assimilation of the Nitrites by Green Leaves in Sunlight.*" By Prof. B. MOORE, F.R.S.

Dilute solutions of nitrates exposed either to sunlight or to a source of light rich in light-energy of short wavelength (such as light from mercury vapour arc enclosed in silica) undergo conversion of nitrate into nitrite.

There is an uptake of chemical energy in this reaction transformed from light-energy as in formation of organic carbon compounds in foliage leaves; it is to be added to the relatively small number of endothermic reactions induced by light.

Interposition of a layer of glass between source of light and solution of nitrate greatly slows the reaction, showing that the most effective rays are those of short length.

When green leaves are immersed in nitrate solution comparatively little nitrite accumulates, indicating that nitrites are rapidly absorbed by the green leaf. Nitrates taken up by plants from soil would, in presence of sunlight, be changed to nitrites which are much more reactive than nitrates. This indicates that the early stages of synthesis of nitrogenous compounds are carried out in the green leaf and aided by sunlight.

Rain-water collected for considerable time contains no nitrites, all having been oxidised to nitrates, but if exposed to bright sunlight or ultra-violet light for a few hours a strong reaction for nitrites is always obtained.

Freshly collected rain-water or dew always contains a mixture of nitrites and nitrates, as shown by the nitrite test appearing without any previous treatment of the water and the great enhancement of this on exposure to strong illumination.

Air bubbled through nitrite and nitrate-free distilled water gives a mixed reaction afterwards when the water is tested for nitrites and nitrates showing presence of both forms of oxides of nitrogen in air.

There is no hydrogen peroxide or ozone in air at surface level. The fresh odour in open air, commonly referred to as "ozone," is probably nitrogen trioxide which at high dilutions has the odour of ozone. The oxides of nitrogen are probably formed by the action of sunlight, rich in ultra-violet rays, in upper regions of the atmosphere upon air and aqueous vapour.

Attention is drawn to the importance of these actions of light in purification of air and water and enrichment of soils and water by this continuously supplying of matter essential to organic growth, the energy of which, like that for upbuilding of non-nitrogenous organic compounds, comes from sunlight.

"*Transition from Rostro-carinate Flint Implements to the Tongue-shaped Implements of River-terrace Gravels.*" By J. R. MOIR.

1. Seven flint implements, exhibiting a beak-like pro le, have been found, associated with early palæoliths, in certain ancient valley gravels.

2. The carina of the rostro-carinate implements was apparently used as a cutting and scraping edge. This edge was extended gradually from the anterior to the posterior region of the implement. This extension resulted in the diminution and final disappearance of the dorsal platform.

3. The rostro carinate is triangular in section and has one cutting edge represented by the apex of the triangle.

4. The earliest palæoliths have two edges and the section is roughly rhomboidal.

5. This rhomboidal form was probably attained by a gradual reduction in width of the ventral surface of the rostro-carinate form until a sharp cutting-edge was produced.

6. It is necessary to form two flat "striking platforms" when making a rostro-carinate or a palæolith. In the latter the remains of one or both of these platforms may sometimes be seen towards the posterior region of the implements.

7. The implements described exhibit certain characteristics of form only before seen in the rostro-carinates discovered beneath the Pliocene Red Crag and in other pre-palæolithic deposits in East Anglia. They show also by the nature of their flaking and provenance that they are of early palæolithic age.

8. The dual character of these specimens is very marked, and points to the conclusion that the knowledge of the manner in which to make a palæolith was acquired by long experience in producing rostro-carinates. This view finds support in the experiments in flint flaking which have been carried out.

9. The specimens have been recovered from a wide area in Southern England, and it seems reasonable to regard them as presenting transitional types linking the rostro carinates with the earliest palæoliths.

CHEMICAL SOCIETY.

Ordinary Meeting, December 6, 1917.

Prof. W. J. POPE, M.A., D.Sc., F.R.S., President, in the Chair.

REFERENCE was made to the loss sustained by the Society, through death, of the following Fellows:—Alexander Macomb Chance and William Ralph Dodd.

Messrs. A. J. Daly, S. Albert Pearman, H. E. Cox, T. van B. Gilmour, G. J. Francis, and F. W. Gamble were formally admitted Fellows of the Society.

Certificates were read for the first time in favour of Edgar Alfred Coakill, 4, Market Parade, Brimsdown; Ransome Wallace Cooper, Chiltern Place, Beaconsfield; Thomas Crowdy, 13, Clifton Road, Devizes Road, Salisbury; John Clare Newlands Eastick, 137 Upper Clapton Road, E. 5; Thomas Fraser, B.A., The Grammar School, Cirencester; Julius Geldard, 610, St. Helens Road, Bolton; William Frank Grant, B.Sc., The Normal Training College, Bloemfontein, O.F.S.; William Robinson Grist, Finsbury Technical College, Leonard Street, E.C. 2; Joseph Eli Hanson, Quarry House, Ossett Lane, Earlsheaton, Dewsbury; Thomas John Hitchcock, 28, Albany Road, Manor Park, E. 12; Harold Housley, M.Sc., Huntsville, St. Andrews Road, Huddersfield; Kumudchandra Ghelabhai Laiwala, M.A., B.Sc., care of Messrs. Thomas Cook and Son, Ludgate Circus, E.C. 4; Harold Lawrence, Ridgs View, 81, Foxley Lane, Purley, Surrey; Elias Mendoza, 53, Manor Road, N. 16, Theketh Kumaran Nair, B.A., B.Sc., East Indian Railway, Jamalpur, India; Horace Finningley Oxley, B.A., care of Messrs. Levinstein, Ltd., Blackley, Manchester; Henri Marc Pezzani, 3, Staff Quarters, Eastriggs, Dornock; David John Prichard Phillips, B.Sc., Pemberton Stores, Burry Port; Snow Blagburn Tallantyre, B.Sc., 14, Inglewood Road, West Hampstead, N.W. 6.

Messrs. R. G. Fargher and Chas. Gilling were elected Scrutators, and a ballot was held for the election of Fellows. The following were subsequently elected as Fellows of the Society:—William Gordon Adam, B.A.; Pierce Alfred Arnold; Jack Reginald Hanlon Bartlett; Albert John Bishop, B.Sc.; Elon Bond, B.Sc.; Fred Bridge; Rainald Brightman, M,Sc.; Robert Lidwill Brown; Arthur Calvert; Sarat Chandra Chatterjee, M.Sc.; George William Chester; Ukrendra Nath Rai Chowdhuri; Edward de Wykersley Swift Colver, D Met.; Henry Joseph Cunningham, B.Sc.; Tom Dempster; Arthur Doulton Dibley; William Alexander Dickie, B.Sc.; John Don, M.A., B.Sc.; Vernon Edge, B.Sc.; Charles Alfred Edwards, D.Sc.; Herbert Wilfrid Erhrhardt, M.A., B.Sc.; George Herbert Frank; Harold Hollings, M.Sc.; John Gordon Hume; George Henry Johnson; James Ivor Morgan Jones, B.Sc.; Reginald Arthur Joyner, M.Sc.; Benedict Trembath Kitto; Oscar Alfred Le Beau, B.A., B.Sc.; Jacob Longman, B.A.; Thomas Henry Malliagh; Edward Bradford Maxted, B.Sc., Ph.D.; Robert Binnie Pettigrew, M.A.; Robert Ignatius Phipps, B.Sc.; Constant Nicolas Polychronis, M.Sc.; Arthur Stanley Quick; Humphrey Rivaz Raikes, B.A.; Alfred Arthur Roberts; Harold Salt; Shinjiro Sato, M.Sc.; Gerald Creagh Scully, M.A.; Alfred Thomas Stanley Sissons, B.Sc.; James Carter Spensley, M.A.; George Spurge; Henry Stephen, M.Sc.; Disney Younger Watt; Albert Francis Wenger; David Emrys Williams, B.Sc.; Ernest Perry Bradley Wilson; Frederick Charles Wood, B.Sc; Joseph Harry Wood.

Dr. F. L. PYMAN delivered a lecture entitled "The Relation between Chemical Constitution and Physiological Action." A vote of thanks to the Lecturer for his Address, proposed by Prof. H. E. ARMSTRONG and supported by the PRESIDENT, was carried with acclamation.

Ordinary Meeting, December 20, 1917.

Prof. W. J. POPE, M.A., D.Sc., F.R.S., President, in the Chair.

Certificates were read for the first time in favour of Robert Fleming, B.A., 2, Wathour El Moyah, Cairo, Egypt; Ernest Hardiker, 3, Park Street, Bolton; Owen Rhys Howell, B.Sc., Darley House, Venner Road, Sydenham, S.E. 26; Arnold Bradley Lownes, 78, Wellesley Road, Ilford; Arthur Macdonald Munro, M.A., 44, Rossett Road, Blundellsands, Liverpool; Robert Atkinson Oddy, The Laboratory, Abbey Street, Toad Lane, Rochdale; John Cameron Clarke Taylor, 2, Queensbury Terrace, Cummertrees, Annan; Hugh Arwel Thomas, B.Sc., 9, Church Circle, S. Farnborough; Albert Edward Timmins, 81, Teasdale Road, Walney, Barrow-in-Furness: Leonard Ellerton Vlies, Belmont, Gowan Road, Manchester, S.W.; Glen Raymond Wakeham, B.Sc., Stanborough Park, Watford, Herts; Godfrey Warburton, Gas Works, Ponders End; Harry Wignall, M.Sc., 16, Roseneath Road, S.W. 11.

The following papers were read:—

"Synthesis of 3:4-Dihydroxyphenanthrene (Morphol) and of 3:4-Phenanthraquinone." By G. BARGER.

"Vacuum Balance Cases." By B. BLOUNT.

PHYSICAL SOCIETY.

Ordinary Meeting, November 23, 1917.

Mr. W. R. COOPER, M.A., Vice-President, in the Chair.

A PAPER, entitled "*Some Problems of Stability of Atoms and Molecules*," was read by Prof. J. W. NICHOLSON, F.R.S.

The paper is mainly concerned with the possible existence and stability of atoms, and of molecules formed after the manner suggested by Stark, the link between the atoms in a molecule being provided by a stationary electron on the molecular axis. Atoms on the Rutherford model, though dynamically unstable, are stable for the simple vibrations ordinarily excited; but it is shown in the paper that atoms with such a stationary electron have a much more limited degree of stability. Moreover, they cannot exist even in an undisturbed state unless they are endowed with a negative charge, for no steady motion is possible, and this conclusion extends even to atoms regulated according to a dynamics such as that of Bohr.

Stark's conclusions do not therefore survive a quantitative treatment, and molecules cannot be formed in the manner he supposes.

The paper also discusses the more symmetrical problem, in which there are two such stationary electrons in an undisturbed atom, and it is shown that systems with a transitory existence, which are known by their spectra to occur in the solar corona, are apparently unaccompanied by the still more transitory systems which would be formed by the attachment of an electron after the manner of Stark. *This is a further argument against the possibility that two atoms in a molecule can be linked by a single electron*, or by two electrons, which attract both atoms.

DISCUSSION.

Mr. T. SMITH asked if it would be possible to make some such generalisation as that symmetry in the system was essential to stability.

Dr. BORNS asked what was meant by the statement that the atom with $+5e$ and $-7e$ is strongly represented in the solar corona.

Dr. R. S. WILLOWS said it was of great advantage that eminent mathematicians were investigating the suggested models of the atom and attempting to compare the results with experiment. Stark had make some brilliant experimental discoveries, but his theoretical deductions appeared to be faulty.

Prof. NICHOLSON, in reply, said he thought some such generalisation as that suggested by Mr. Smith could be made. At any rate, the greater the symmetry of the system the more liable it is to be stable. In reply to Dr. Borns, he meant that certain lines of strong intensity in the spectrum of the corona were referable to such a system.

An Exhibition of the Uses of certain Methods of Classification in Optics was given by Mr. T. H BLAKESLEY, M.A.

This consisted of an account of the additions which, in the course of the intervening years, he had been enabled to make in the general diagram of optical properties, first communicated by him to the Physical Society in the year 1903 (*Proc.*, xviii., 591). The plan pursued is to take as variables the relations which the radii of face curvature bear to the thickness between the faces along the axis. By this means the shape of the lens is given by the two rectangular co ordinates alone, and any possible property dependent upon a function of these co-ordinates will be represented by a line upon the diagram. When two such loci intersect, the lens corresponding to the points of intersection possesses both the properties corresponding to the lines. A point much dwelt upon by the author was the very large number of straight-line loci corresponding to properties of value in a lens, and of these very many are parallel, and, cutting the axes at 45°, may be most simply defined by the value of the intercept of the axis.

It was pointed out that, in general, a lens may have its radii of face curvature both multiplied by the same factor without changing in sign or value the focal length. One of the above-mentioned loci at 45° to the axes represents the only family in which this change cannot be effected, from the fact that the factor in this case is unity. Another of these straight lines belongs to a family in which the two focal lengths corresponding to two assigned indices of refraction are equal; and closely allied to this is a family for which the focal length is a minimum for an assigned value of index.

In another family of the kind the property is that a lens may be immersed in another medium without having its focal length changed.

In another, if a lens is cut out of a cylinder of glass, the remnants of the cylinder in their original position will be achromatic.

In another, telescopic; and so for many others. Other straight lines exist which are not parallel to those above mentioned. They often refer to matters connected with the passage at minimum deviation through a lens, and sometimes to what are called self-conjugate points.

The detection of lens properties which are independent of one of the face curvatures was explained and some few cases pointed out—*e.g.*, when a lens has one of its radii of face curvature equal to the thickness of the lens at the axis, it matters not what curvature is given to the other face, the point of magnification equal to the index will be coincident with its own conjugate point—*i.e.*, for the point of magnification equal to the inverse of the index for the other side of the lens; and this whichever way the light is passed through the lens.

There are two lines upon the diagram, both straight lines, which refer to the silvering of the second surfaces of lenses, so as to produce plane virtual mirrors; one performs this by sending the centre of the virtual mirror to infinity, the other by sending the surface of the virtual mirror to infinity. In the latter case, which alone calls for special remark, light, though entering the system at an angle, returns upon the same path, always producing an inverted image of -1 magnification, crossing the object at the virtual centre.

DISCUSSION.

Mr. T. SMITH suggested that the author might add a number of curves to his diagram showing the aberration properties of lenses. There were a number of other geometrical loci that might also be added. It usually happened that the lenses required in actual instruments had too long radii in comparison with the thickness to be included in the region covered by the author's diagram, and it was usually better to calculate each lens by known methods than to extract them from a diagram.

Mr. S. D. CHALMERS said he had on occasion found diagrams somewhat similar to Mr. Blakesley's, but in which the inverse of the radii of curvatures were employed, to be of considerable service in certain problems.

Mr. BLAKESLEY did not think Mr. Chalmers's system would lead to so many straight-line loci as his own. He thought straight-line loci had some advantage if they could be obtained.

SOCIETY OF GLASS TECHNOLOGY.

Ordinary Meeting, December 19, 1917.

Prof. W. G. FEARNSIDES in the Chair.

THE following papers were read :—

"*Resources of Potash Suitable for Glass Making in the United Kingdom.*" By Prof. P. G. H. BOSWELL, D.I.C., F.G.S.

The mineral resources available as sources of potash may be divided into two classes—(1) Soluble salts, (2) Insoluble salts. Up to the present no sources of soluble potash salts are available in the British Isles to replace those previously obtained from Stassfurt and Alsace. Among available insoluble salts may be mentioned felspar, mica, leucite, and glauconite, all of which are silicates.

The demand for potash is very large at the present time, being required for pottery, enamel, glass, soap, chemicals, explosives, and in agriculture. The most productive source is likely to be found in felspar, which is useful for the alumina it contains as well as the potash. Felspar is a family name which includes many minerals, the two chief groups being—(1) potash felspar; (2) silicates of lime and soda.

Felspars are of wide occurrence. Granite consists of quartz, felspar, and mica which have crystallised out more or less together. Unfortunately the felspar is too small in grain to be picked out, and so granite cannot be used as a source of felspar. Granite occurs up and down the country in huge masses, and often at the margins and scattered throughout the mass in veins is found felspar. Such a vein is usually known as pegmatite, and the veins of it may vary from 40 ft. in width to a few inches. It is a valuable source of felspar, as the latter is found in large easily picked pieces. Pegmatites are only to be found in

the most inaccessible spots—the North West of Scotland, the North West of Ireland, and in Cornwall. The sites of the chief deposits were shown on a map.

The two chief varieties of felspar are known as monocline and orthoclase, the difference lying in the crystalline form. Orthoclase is to be preferred, as there is less tendency of this form to form mixed crystals with soda felspar. Pegmatite consists of felspar and quartz in large pieces and must be hand picked, the felspar being in crystals 3 to 4 inches long. Sometimes the felspar is intergrown with the quartz and the rock is then known as perthite.

Felspar is prone to decomposition, brought about by gases and solution from below and by atmospheric action. The alkalis are leached out leaving the silica and alumina as clay. When the leaching is done from below the final product is very pure china clay.

For pottery felspar should be low in quartz, low in soda (to prevent crystallisation), and low in iron (to obtain good colour). The same features are necessary for glass-making, and in addition there ought to be constancy of composition. Unfortunately this could never be realised. A potash content of 10 to 12 per cent was desirable for glass-making felspar, and the soda content should not be more than 3 per cent, the iron content not more than 0·1 per cent.

All the British felspars are of the monocline type except the Roche deposit in Cornwall, which is orthoclase. The chief deposits in Scotland are in the vacinity of Loch Lanford, Durness, and Overscaig. In Ireland felspar is found at Belleek, Belmullet, and Glenties; whilst good felsite is obtainable in Waterford and Wicklow, although its iron content is high.

There seems little prospect of British felspar being placed on the the market as cheaply as the pre war Scandinavian supplies, owing to the cost of transport in this country and also the higher price and different conditions of labour.

Of late many methods have been patented for the extraction and recovery of potash. It is hoped that a rich source of potash may be found in the flues of cement kilns and blast furnaces. Possibly it will be found expedient to boost up the amount of potash in the flues of cement kilns by using felspar in the manufacture of cement.

The lecture was ably illustrated by lantern slides and maps, and gave rise to an animated discussion.

Prof. Fearnsides pointed out that since vegetation contained potash, and coal was of vegetable origin, then coal must contain potash. This would not be found in the ash as it would have volatilised but would be found in chimneys and flues. Possibly the manurial value of soot lay in the potash it contained. Again sedimentary rocks being the disintegration products of igneous rocks (which all contain potash) might conceivably be a source of potash. Sands and limestones contain very little, and so would not pay for extraction, but clays might very well do so.

Mr. Rees confirmed Dr. Boswell's remarks regarding blast furnace and cement kiln dust being a valuable source of potash.

Mr. C. J. Peddle pointed out that felspar was regarded by glassmakers as being important as much for the alumina as for the alkali it contained. It was a cheaper method of giving glass all the beneficial results conferred by alumina than by using the calcined oxide, and was far more suitable than china clay for this purpose.

Mr. Davidson and Mr. Foster joined in the discussion and Prof. Boswell replied.

"*Bolsterstone Glass.*" By Joseph Kenworthy.

The history of glass-making was traced from legendary times until its introduction into England in a most interesting manner. The subsequent vicissitudes of glass manufacture in this country were then dealt with more fully, leading up to the manufacture of glass in Bolsterstone, an out of the way spot in the Don valley. The author had collected a large amount of information about this ancient and now long defunct manufactory, and illustrated a most fascinating account by means of beautiful glass specimens and by photographs. The first glass house at Bolsterstone seems to have been built about 1645 by George Fox, and after passing through various hands was closed down about 1750. It was in the heyday of its existence when worked by Robert Blackburn, and at that time was turning out very good glass of all varieties of table ware and domestic ware. Much of the glass made here has been lost or disseminated throughout the country, but some beautiful specimens both from point of colour and design are still in existence.

The next meeting of the Society will be held at Stourbridge on January 16, 1918.

NOTICES OF BOOKS

The Chemistry of Linseed Oil. By J. Newton Friend, D.Sc. (B'ham.), Ph.D. (Wurz.), F.I.C. London: Gurney and Jackson. 1917. Pp. vii+96. Price 2s. 6d. net.

The author of this monograph aims at stimulating interest in the chemistry of the oils, in which many problems of great practical importance require further investigation before satisfactory explanations can be given. The little book will be found excellent for its purpose, and it contains plenty of suggestions for research work. Both teachers and advanced students will find it stimulating reading, and although the treatment of the subject is necessarily not detailed a great deal of information is packed into small compass. An outline is given of the manufacture of the oil, and the chemistry of the chief constituents and the properties of the oil and the action of reagents upon it are considered comparatively fully. A valuable feature of the book is the very complete bibliography which, besides giving titles and details of a great number of works dealing with linseed oil, adds useful explanatory notes and short discussions of points of interest.

Present Conditions in Relation to Food Supplies. By Alfred Smetham, F.I.C. Pp. 24. Price 1s.

This paper, which is reprinted from the *Journal of the Royal Lancashire Agricultural Society* for 1917, contains a clear discussion of the question of food values and the food requirements of the population. The author takes the "men" population to be 77 per cent of the total mixed population, and works out the quantities of carbohydrate, fat, and protein necessary for the maintenance of the population in a state of efficiency and comfort. He emphasis s the importance of wheat production and the wastefulness of cattle feeding, stating that the nation could live ten times as long on a given quantity of wheat used as such as it could if the same quantity was employed for the production of "steer" beef. The suggestions of the Committee of the Royal Society as to methods of saving food are carefully discussed, and the paper provides a thoroughly scientific summary of the main aspects of the question of the food supply and the most pressing needs in regulating production.

The National Physical Laboratory, Report for the Year 1916-1917. Collected Researches. Vol. XIII, 1916. London: Harrison and Sons. 1916. Pp. 67, 299. Price 20s.

The report of the National Physical Laboratory, as was to be expected, shows that all the work done has been greatly affected by war conditions, and there has been a deplorable but quite unavoidable decrease in research work of general utility. On the other hand, an enormous

amount of testing of apparatus and materials has been carried through, the growth of the gauge testing work being specially noticeable. It is not possible to issue a programme of work for 1918, but if opportunities occur some of the suspended researches will be taken up again, while the investigation of problems arising out of the war will, of course, be continued with the utmost vigour. The volume of collected researches contains seventeen papers, of which many are on optical subjects, such as the calculation of thin objectives, lenses for light distribution, &c. With the exception of the first paper on "Constructional Data of Small Telescope Objectives Calculated at the National Physical Laboratory" and the last, a "Report on Tests of Fuel Oils, carried out for the Royal Commission on Oil Fuel," all have been reprinted from various scientific journals, such as the *Proceedings of the Physical Society*, the *Journal of the Institute of Metals*, and the *Journal of the Institution of Electrical Engineers*.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

NOTE.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxv., No. 13, September 24, 1917.

New Method of Separating Tin and Tungsten in Stanniferous Wolfram.—M. Travers.—The separation of tin and tungsten is one of the most delicate operations in analytical chemistry. The method which the author describes has given satisfactory results in the analysis of many metals, even those rich in tin (50 per cent). The mineral is fused in a muffle at a bright red heat in a porcelain crucible with anhydrous sodium sulphite; the fused mass is dissolved in boiling water, and the solution made up to 700—800 cc., and slightly acidified. Brown stannous sulphide is precipitated, carrying down a little silica and sulphides of iron and manganese, but no tungstic acid. The precipitate of stannous sulphide is purified by dissolving it in ammonium sulphide containing sulphur; by precipitation yellow stannic sulphide is obtained and calcined to give SnO_2. The tungsten is determined by attacking another portion of the specimen with anhydrous sodium sulphite, and taking up the fused mass with concentrated acids ($HCl + HNO_3$). The greater part of the tungsten is at once precipitated as tungstic acid, mixed with silica. The liquid is precipitated with ammonia, and the precipitate of iron oxide thus obtained is dissolved with hydrochloric acid; on evaporation to dryness and solution in HCl all the tungstic acid is obtained.

No. 14, October 1, 1917.

X-Ray Spectra of Isotopic Elements.—Manne Siegbahn and W. Stenström.—The authors have examined the X-ray spectrum of a preparation of RaG with that of ordinary lead. The atomic weight of the preparation was 206·05, while that of ordinary lead is 207·18. The wave-lengths of the spectra were found to be the same. It has already been shown that the ordinary spectra, visible and ultra-violet, are also identical.

No. 15, October 8, 1917.

This number contains no chemical matter.

MISCELLANEOUS.

The Library Association.—In the Interim Report of the Council of the Library Association on the Provision of Technical and Commercial Libraries the proposal is made that funds should be provided for some State-supported Library, such as the Science Library of South Kensington, or a Library controlled by the Department of Scientific and Industrial Research, to purchase books required for research, and to make them available for loan to public libraries. Such a library would undoubtedly be a great boon to students and scientific men generally, and the fuller report of the Association, which will be published shortly, will be awaited with interest.

The Nitrogen Industry.—The October number of the *Canadian Chemical Journal* contains a long article on the Nitrogen Industry and its Prospects, in which a summary is given of the Report of the U.S. War Department on the Nitrogen Industry with Recommendations. The advantages and disadvantages of the various methods of synthesising nitric acid are carefully weighed, and the general conclusions reached by the author, Mr. C. L. Parsons, Chief Chemist to the Bureau of Mines, U.S. Department of the Interior, are given in detail. The paper gives a very clear analysis of different methods of preparing nitric acid, and contains the latest data as to output, costs, &c.

New Method for the Recovery of Salts of Potassium and Aluminium from Mineral Silicates.—In the *Journal of Industrial and Engineering Chemistry* (October 1, 1917, vol. ix., No. 10) a paper by J. C. W. Fraser, W. W. Holland, and E. Miller, on the preparation of salts of potassium from felspar and sericite, which was presented at the Buffalo meeting of the American Institute of Chemistry, is reproduced. The authors showed that by the treatment of felspar with strong alkali a substance analogous in composition with leucite could be obtained. Finely-ground felspar was mixed with about 0·8 of its weight of potassium, or the equivalent quantity of sodium hydroxide, dissolved in a little water, and heated in an open iron vessel until the water had evaporated, and then for about an hour to a temperature of 270—300° C. The following reaction occurred, the new silicate formed having approximately the composition of leucite, $KAlSi_3O_8 + 2KOH = KAlSi_2O_6 + H_2O + K_2SiO_3$. It is insoluble in water, and can thus be separated from the excess of alkali and the alkali silicate. All the alkali can be recovered by causticising the solution with lime and filtering off the calcium silicate separated. The "artificial leucite," which contains all the potash and alumina, and two-thirds of the silica of the original felspar, can readily be made to yield up its constituents, the potash being very much more loosely held then the aluminium. If the silicate is suspended in water between two platinum electrodes on passing a current practically all the potassium can be obtained as potassium hydroxide, or the potassium contained in the silicate can be titrated with a mineral acid, a fairly satisfactory end-point being obtained if sufficient time is taken towards the end of the operation. For the extraction the silicate is mixed with water and dilute hydrochloric acid in amount equivalent to the potassium content of the silicate is added slowly with constant stirring. The potassium chloride solution is removed from the insoluble aluminium silicate by filtration. If this aluminium silicate is treated with sulphuric acid in quantity equivalent to the aluminium it contains, aluminium sulphate is produced and gelatinous silica separates. The yield of potassium chloride thus obtained is practically theoretical, while that of the aluminium is about 86 per cent af the theoretical.

MEETINGS FOR THE WEEK.

SATURDAY, 5th / TUESDAY, 8th.—Royal Institution, 3. (Christmas Lectures, adapted to a juvenile auditory). "Our Useful Servants - Magnetism and Electricity," by Prof. J. A. Fleming, F.R.S.

MONDAY, 7th.—Society of Chemical Industry, 8. "The Toxicity of Methyl Alcohol in Relation to its Industrial Uses—a Review of the Published Data," by T. D. Morson "Rapid Estimation of Pyridine in Ammonia," by T. F. Harvey and C. F. Sparks. "Corrosion of Lead Roofing" and "Action of Rainwater on a Portland Stone," by J. S. S. Brame.

THE CHEMICAL NEWS

Vol. CXVII., No. 3033.

THE VISCOSITY OF BLAST-FURNACE SLAG AND ITS RELATION TO IRON METALLURGY, INCLUDING A DESCRIPTION OF A NEW METHOD OF MEASURING SLAG VISCOSITY AT HIGH TEMPERATURES.*

By ALEXANDER L. FEILD, B.A., M.S. (North Carolina), Assistant Metallurgist, United States Bureau of Mines, Pittsburgh, Pa.

Introduction.

The general physical and optical properties of the natural silicates, such as the felspars, micas, and pyroxenes, have been known to petrographers for a number of years. Researches on silicates at high temperatures are, however, of comparatively recent origin, due to the experimental difficulties involved in high temperature investigations, and the fact that accurate means of measuring high temperatures, as well as the establishment of the high-temperature scale itself, are matters successfully accomplished within the last decade.

Before the genesis of the science of pyrometry and the construction of laboratory electric furnaces capable of accurate temperature control, observations on natural silicates and artificial silicates, such as glasses, were confined to determinations at ordinary temperatures of such physical properties as density, coefficient of expansion, hardness, thermal conductivity, specific heat, refractive index, dielectric constant, optical rotary power, and coefficient of absorption. A knowledge of these properties, while indispensable in certain cases, cannot serve the purpose of elucidating the physical properties of the silicates at elevated temperatures. H. Le Chatelier (*Note* 1) has recently published in book form an excellent treatise on the general properties of silica and the silicates, which also contains brief reference to the earlier high-temperature investigations.

The scientific investigation of the silicates at high temperatures may be considered to have had its origin in 1880, when Dr. Carl Barus was appointed physicist of the United States Geological Survey for the purpose of determining the formation temperatures of the rocks which form the earth's crust (2). Barus devoted himself in part to the development and application of the thermocouple to high-temperature measurement at a time when Le Chatelier in France was attacking the problem independently. This work received a new impetus in 1900, when Dr. Arthur L. Day took up the work and introduced the high-temperature scale and methods of the Reichsanstalt into the United States Geological Survey. Soon after this date these investigations were taken over by the Carnegie Institute of Washington, which resulted later in the founding of the well-known Geophysical Laboratory.

It is with a certain pleasant sense of continuity of effort that I recall the fact that the investigations which form the subject of this report from the Bureau of Mines, although instituted in the late fall of 1915, can claim a certain inherited relationship to the early work of Barus and Day; for the Bureau of Mines, some several years before its organisation as a separate Bureau, was known as the Technologic Branch of the Geological Survey.

During the years immediately following Barus' ground-breaking work the study of the silicates at elevated temperatures steadily grew. In 1886 Seger (3) published his work on "Standard Cones for the Measurement of Temperatures in the Kilns of the Ceramic Industries." In 1888 Callendar (4) described his improved form of the Siemens resistance thermometer, while Joly (5) in 1891 invented the micropyrometer which bears his name. In 1892 Le Chatelier (6), acting upon a suggestion originally made by Becquerel (7), devised the optical pyrometer which bears his name, which, according to recent experiments by Waidner and Burgess (8), is as accurate in its measurement of temperature as other more recent types, such as the Wanner (9) (1901) and the Féry (10) absorption (1904) optical pyrometers. About the same time Holborn and Kurlbaum (11) in Germany and Morse (12) in the United States brought out an optical pyrometer using a new photometric method. The former of these, the Holborn-Kurlbaum, is generally considered to be the most precise instrument on the market, and is, according to Waidner and Burgess (13), capable of a precision of 2° at 1500° C. In 1902 Féry (14) devised a pyrometer utilising the energy of total radiation.

Joly (15) determined the melting-points of a number of minerals by means of his novel apparatus, temperatures being estimated by the linear expansion of the strip of heated platinum foil upon which the small test grains were placed. The melting-point was estimated by noting the occurrences of deformation or incipient fusion, and hence should be classed as a softening temperature rather than a melting-point. In 1901 Cornelio Doelter (16) began the publication of an extended series of experiments on the melting-points of minerals, using thermocouples for measuring temperature and electric furnaces modelled after those of the Reichsanstalt, as used by Holborn and Day. Doelter, as did Joly, used a purely subjective method for estimating the melting-point, and recorded two temperatures – the first approach of viscous melting and the point where the material appeared to have gone over into a thin liquid. It appears, then, that both Joly and Doelter have determined the temperature at which the various minerals investigated approached a more or less definite viscosity, rather than the true physical melting-point.

Since 1905, when Messrs. Day and Allen (17) published their important work on "The Isomorphism and Thermal Properties of the Feldspars," the contributions from the Geophysical Laboratory of Washington on the melting-points and the stability relations of the silicates at high temperatures have formed the greater part of authoritative high-temperature research on the properties of the silicates, most of these publications having appeared in the *American Journal of Science*.

In view of the comparatively short existence of accurate pyrometry and of accurately controlled laboratory furnaces, it is not surprising that Sir Lowthian Bell in his admirable investigations on the manufacture of pig iron in the blast-furnace, which were published in 1884 (18), was seriously handicapped in so far as the determination of high temperatures was concerned; and also that Akermann (19), in his painstaking determination of the "total heat" of slags by the calorimetric method, was not able at that time (1886) to estimate the temperature of the slag melts which were investigated, but rather was forced to refer his measurements to a more or less indefinite "pouring temperature."

Since the introduction of modern methods a limited number of properties of the silicates have been investigated at high temperatures, apart from the extensive work on melting-points and phase-rule diagrams. Day, Sosman, and Hostetter (20) have recently devised a method for measuring the density of minerals at temperatures up to 1600° with an accuracy of from 0·2 to 0·5 per cent, supplanting the earlier work of Barus (21) and Doelter (22). Measurements are given on quartz, granite, and diabase. White (23) has determined the specific heat of orthoclase, orthoclase glass, diopside, wollastonite, pseudo-wollastonite, and a soft glass up to a temperature of 1300° C. with an accuracy estimated to be within 0·5 per cent. Doelter (24) has made a number of measurements recently

* A Paper communicated to the *Transactions of the Faraday Society*. Published by permission of the Director, U.S. Bureau of Mines.

on the electrical conductivity of silicates at high temperatures.

Although the authentic data which have recently accumulated on the behaviour of the silicates at high temperatures possess a great interest and value from the standpoint of the mineralogist and the geophysicist, a knowledge of the physical melting-points and fields of stability of the silicates is not the most important factor for consideration in so far as application to the metallurgy of iron is concerned. In a study of the blast-furnace we are particularly interested in the behaviour of the slag from the time it enters the zone of fusion until it is flushed from the cinder-notch. In transit through this region where the smelting process occurs the most important physical property of the slag is its viscosity, while its most important chemical property is its desulphurising power, or ability to absorb the sulphur of the charge.

It was early apparent to furnacemen that blast-furnace slag in the molten condition was much more "viscous" or "viscid" than molten iron and the fused salts of ordinary acids, and that the slag underwent a gradual softening on heating rather than a sudden change to a mobile liquid, as is characteristic of sodium sulphate, for instance. This particular characteristic was from the first rightly attributed to the silica content of the slag, rather than the lime or alumina content; for, while both lime and alumina combine with a number of different acids to form solids which upon melting exhibit no unusual degree of viscosity, the presence of silica in a chemical compound usually confers upon it a high viscosity in the liquid state. This peculiar property appears to be due to the nature of the molecule SiO_2 rather than to the element silicon itself, for, as is well known, $SiCl_4$ is a volatile colourless liquid, which boils at 59° C., while SiF_4 is a gaseous substance, which has a boiling-point of —100° C.

In 1913 Dr. Laue, of the University of Zurich, conceived the idea of employing a crystal as a "space diffraction grating" for X-rays. This epoch-making discovery, in the hands of Messrs. W. H. and W. L. Bragg, has yielded extremely interesting facts concerning the structure of crystalline solids. To quote from the latter investigators, "The architecture of crystals has been laid open to examination; crystallography is no longer obliged to build only on the external forms of crystals, but on the much firmer basis of an exact knowledge of the arrangement of the atoms within." Hitherto the chemical molecule had been supposed to exist as such in the solid state. The X-ray spectrometer, however, has shown clearly that in the case of most crystals each atom is arranged in an ordered manner at definite points of a "space-lattice," and that in the case of a crystal of potassium chloride, for instance, there is no such thing as a molecule of KCl in the usual sense of the word, but that each potassium atom is equidistant from six chlorine atoms, while each chlorine atom is equidistant from six potassium atoms. In other words, the valence of each potassium atom and chlorine atom is divided between at least six complementary atoms. When W. H. and W. L. Bragg took up the examination of quartz (25), *i.e.* SiO_2, by means of this method, they found that it presented a structure more complicated than that of any substance which they had at that time investigated.

Instead of finding that silicon and oxygen atoms were arranged separately at definite points of a space-lattice, Messrs. Bragg concluded that *three silica molecules* were associated with each point of the space-lattice. It is a matter of common knowledge that highly associated or polymerised liquids possess unusually high viscosity; and hence it seems plausible to argue that, since silica appears to be unusually complex in the solid state, in the liquid state this association or polymerisation tendency must be the fundamental cause of the extreme viscosity of silica itself and of the high viscosity of the silica compounds. This explanation, as based on X-ray analysis, does not seem to have been brought forward hitherto in dealing with the cause of the high viscosity of silicates.

Irving Langmuir (26), in a valuable contribution to the theory of the constitution of solids and liquids, has very recently reviewed the work of the Braggs on crystal structure from the viewpoint of the chemist and the relation of this work to theories of chemical constitution such as those of Werner, Stark, J. J. Thomson, and Lewes. Langmuir considers the complex silicates as apparently built up of compounds of the first order, *i.e.*, atomic groups held together by "primary" valence, which are in turn held together by secondary or residual valence, in much the same way that the metallic compounds are built up of the atoms of the metals. He further states (27): "From the fact that glasses, when heated, change to the liquid state by a continuous process, we are led to conclude that the structure of a liquid does not differ from that of a glass in any essential respect except that in the liquid there is a certain mobility (entirely analogous to tautomerism). Therefore, even in a liquid we look upon every atom (or group-molecule) as combined chemically (or adsorbed) to all the adjacent ones. The molecular weight is therefore a term that has very little significance in the case of a liquid." When, therefore, a silicate gradually softens with rising temperature and passes entirely over into the liquid state, it is probable that the increased fluidity is due to a weakening of the residual-valence attraction between the group-molecules, whereas the relatively high viscosity of the melt, as compared with that of molten metals and ordinary salts, is due to the preponderance of the group-molecules of silica, alumina, and lime, and possibly to a particularly large degree upon a highly polymerised condition of the silica group-molecule.

Slag Viscosity as related to Fuel Economy.

While it is theoretically possible to render any silicate mixture whatsoever sufficiently fluid to flow from the cinder-notch of a blast-furnace, it is necessary in practice that a slag attain this necessary fluidity at a temperature which is not beyond the working limit of the blast-furnace lining and which does not demand an unusually high fuel consumption.

It is obvious that if, for instance, a slag requires a minimum temperature of 1400° C. in order to attain a working fluidity, no iron will be produced in a furnace using this slag, regardless of the number of B.T. units developed within the furnace, unless the temperature-distribution is such that the slag acquires the necessary temperature of 1400° C. Thus the fuel economy of a blast-furnace is to a great extent dependent upon the temperature-viscosity relations of the slag.

The maximum temperature to which it is theoretically possible to heat the slag, assuming an absence of heat loss by conduction or radiation, is the theoretical combustion temperature of the exothermic reaction which occurs near the tuyeres, $C + O \rightleftharpoons CO$, taking into account the fact that the oxygen represented in the equation represents in reality ordinary air. The old style heat-balance of Sir Lowthian Bell considered only quantity of heat and not its intensity, *i.e.*, temperature. According to this early method of calculating fuel economy, five B.T.U. produced in the bosh had a definite significance, regardless of the temperature at which they were produced. It is evident, on the contrary, that any factor which operates so as to increase the combustion temperature in the region of the tuyeres will exert a relatively large effect so far as fuel economy is concerned when compared with a factor which increases the total heat in the furnace without appreciably affecting the temperature of the tuyere region.

When James Gayley (28) published the results of his experiments with the dry blast at the Isabella furnaces near Pittsburgh, it became evident that the gain in fuel economy was greater than that simply represented by the fraction of the total heat developed in the furnace which was contributed by the drying process. Many furnacemen openly questioned the results of the tests. Ledebur, Bell, and Le Chatelier offered in turn unsatisfactory explanations. A. Lodin (29), however, appears to have been the first to

publish an explanation which went to the root of the matter He says, in part:—

"La fusion du laitier par exemple nécessite un certain nombre de calories qui doivent être fournées au-dessus d'une température minimum, celle du point de fusion. Ces calories seront empruntées aux produits gazeux de la combustion de carbone: la seule partie du pouvoir calorifique de celui-ci utilisable pour cet usuage détermine sera celle correspondant au refroidissement de produits gazeux depuis la température de combustion jusqu'au point de fusion du laitier."

In September, 1904, J. E. Johnson presented a paper before the American Institute of Mining Engineers (30), entitled "Notes on the Physical Action of the Blast-furnace," in which was brought forward the idea that the fuel economy of the blast-furnace depends upon the "available heat" furnished above the "critical temperature," this temperature corresponding with the free-flowing temperature of the slag. Johnson's theory differs from that of Lodin in that the former takes the free-flowing temperature of the slag as the "critical" temperature, while the latter assumes it to be the temperature of the fusion slag. Johnson (31) has recently further expounded his theory as substantiated by the results of blast-furnace practice. He *does not in any case point out clearly the physical significance of the term* "available heat" for any given "critical" temperature, although the detailed calculations are given.

The author has shown elsewhere (32) that the "available" hearth heat of Johnson at a critical temperature T is equal to the heat of the isothermal reaction $C + O \rightleftarrows CO$ at a temperature T, minus the heat required to raise the temperature of the blast up to a temperature T, together with that required to decompose the moisture of the blast; and that this available hearth heat includes (*a*) the heat lost by radiation and conduction between those two zones in the furnace which are at the critical temperature, and (*b*) the heat required for those final steps of reduction of ore and carburisation of iron, and other similar adjustments in composition of molten iron, molten slag, and furnace gases, which occur between the "critical zones."

It is evident therefore that the viscosity-temperature relations of the slag do more than simply determine the facility with which the slag is handled at flush and the extent of desulphurisation accomplished within the hearth; these relations are fundamental in determining the fuel economy which can be realised in furnace operation.

The Work of the Bureau of Mines.

The Bureau of Mines is investigating the problem of slag viscosity, its variation with the temperature and with the composition of the slag, and its effect upon the distribution of the sulphur between molten iron and slag. These investigations are being conducted in the laboratories of the Pittsburgh station of the Bureau of Mines, and will represent, when published, an introduction to a series of contributions to the theory of the metallurgical processes.

Acknowledgments.

In reporting the results of the experimental work described in the present article, the author wishes to make acknowledgment of the active interest of Mr. F. H. Willcox, metallurgical engineer, at whose suggestion the work on slag viscosity was undertaken. Acknowledgment is also made of the encouragement and support received from Mr. Van H. Manning, director of the Bureau, at whose authorisation the research was initiated; and of the active co-operation and interest of Dr. F. G. Cottrell, chief metallurgist, and Mr. D. A. Lyon, metallurgist, during the progress of the investigations. The chemical analyses of slags were made by Mr. F. D. Osgood, junior chemist, under the direction of Mr. A. C. Fieldner, chemist.

Appreciation is also due to the numerous iron and steel companies from whom slag samples were obtained; and to the Jones and Laughlin Steel Company and the Clinton Iron and Steel Company of Pittsburgh in particular for their courtesy in permitting measurements to be made at the furnace.

The Application of Viscosity Data to Metallurgical Operations.

Before taking up the description of the viscosity apparatus, furnace, and accessories, and tabulation of the experimental results obtained, it is advisable to consider briefly the application of accurate viscosity determinations on metallurgical slags to manufacturing processes, and also to related research in this field. Particular attention must be given in the present paper to a consideration of the principles of the metallurgy of iron, although in many other metallurgical operations, such as the smelting of copper, for instance, a knowledge of the temperature-viscosity relations of different types of slag is of great importance.

Apart from the question of mining cost and freightage, the value of an iron ore sufficiently rich in iron to be considered marketable is largely dependent upon whether it can be made to yield economically a slag of desirable viscosity and desulphurising power. A casual glance at the table of slag analyses given elsewhere in this paper shows at once the comparatively wide range of slag composition that has been found practicable by different manufacturers. In each case the particular slag composition was undoubtedly determined in a large measure by the composition of the ore mixture and fuel which it was deemed expedient to use, and also by the grade of iron produced. However, it is entirely probable that in certain cases the slag composition was not the optimum one from the standpoint of economy and excellence of product. It is one of the purposes of these investigations to determine what are the optimum conditions.

The experience of furnacemen with practically the same operating conditions differs quite widely in many instances. In fact, each furnace seems to have its own peculiarities. Successful operation is realised by a careful study of the past records of operation and production. Radical changes in operating methods are sometimes made, with results which may or may not be beneficial, and which cannot be predicted beforehand with certainty. This is, in a few words, the general situation in regard to iron metallurgy. Of course there are furnacemen, with a ready gift of intuition, to whom nothing is impossible; but these men are rare, and impart their knowledge with difficulty because of the fact that it is intuitive.

In spite of the lack of scientific research on the physical and chemical properties of slags at high temperature, it is quite well understood what functions the slag must perform in the blast-furnace. In the first place, it must be sufficiently fluid to flow from the cinder-notch at the temperature which exists in the hearth. In the case of charcoal practice, where desulphurisation is a minor item, the viscosity of the slag at flush is a primary consideration. If, for instance, it is found that a silicious charcoal slag possesses a viscosity at 800 at the temperature of the hearth, the question arises whether a limy slag would perform its functions properly if it possessed an equal viscosity. The limy slag may be prevented from performing these functions for one or both of the following reasons. In the first place, the limy slag with a viscosity of 800 might have an extremely high rate of change of viscosity with temperature, *i.e.*, this particular point on the temperature-viscosity curve might occur at a temperature where the slag underwent rapid softening or hardening with small changes of temperature. In the second place, the limy slag might not be at a sufficiently high temperature to properly desulphurise the pig iron.

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(To be continued).

THE CONSTITUTION AND FUNDAMENTAL PROPERTIES OF SOLIDS AND LIQUIDS.*

PART II.—LIQUIDS.

By IRVING LANGMUIR

(Continued from p. 5).

FROM the values of $(F/c)_0$ we can calculate λ the loss in potential energy when a grm. molecule of the solute passes from the interior to the surface of the solution. We have previously shown from Szyszkowski's data how the increase in λ for each CH_2 could be determined. To estimate the approximate absolute value of λ we may proceed as follows:—

It is shown in works on the kinetic theory (for example Jean's, "Dynamical Theory of Gases, p. 78) that for a state of equilibrium the distribution of a gas between two regions in which the potential energy is different, is given by the relation—

$$\frac{c}{c'} = e^{-\lambda/RT} \quad . \quad . \quad . \quad . \quad . \quad . \quad (24).$$

Here c and c_1 are the respective concentrations in the two regions and λ is the difference in potential energy per grm. molecule (The above equation is closely related to Boltzmann's conception, according to which entropy is equal to the logarithm of the probability. The ratio between the probability that a molecule will be in the interior and the probability that it will be in the surface is thus proportional to $e^{-\phi}$ where ϕ is the entropy. The quantity λ/RT corresponds to the entropy).

For solutions so dilute that F/c is constant, we may expect Equation 24 to be applicable, and we may thus use it to calculate the concentration c in the surface layer in terms of λ or vice versa.

The equation may also be derived from purely thermodynamical principles.

If λ is expressed in calories, Equation 24 may be written—

$$\lambda = RT \ln \frac{c_1}{c} = 4{\cdot}57\ T \log \frac{c_1}{c} \quad . \quad . \quad . \quad (25).$$

This equation is similar in form and analogous in meaning to Nernst's equation of the electromotive force of reversible cells.

The amount of solute q absorbed in the surface layer per sq. cm. may be roughly taken to be—

$$q = \frac{\tau(c_1 - c)}{1000} \quad . \quad . \quad . \quad . \quad . \quad . \quad (26),$$

where τ is the thickness of the surface layer in which adsorption takes place.

Combining Gibbs' Equation 1 with (12) we obtain—

$$q = \frac{c}{RT}\left(\frac{F}{c}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (27).$$

Eliminating q from (26) and (27) and combining with (25) gives for dilute solutions—

$$\lambda = 4{\cdot}57\ T \log\left[1 + \frac{1000}{\tau RT}\left(\frac{F}{c}\right)_0\right] \quad . \quad . \quad (28).$$

Taking $T = 288$ and assuming $\tau = 6 \times 10^{-8}$ cm. this equation reduces to—

$$\lambda = 1318 \log\left[1 + 0{\cdot}695\left(\frac{F}{c}\right)_0\right] \quad . \quad . \quad . \quad (29).$$

* From the *Journal of the American Chemical Society* xxxix., No. 9.

This equation was used for calculating the values of $\lambda_{obs.}$ given in Table III. The choice of the particular value of τ to use in (28) is somewhat arbitrary, but since the molecules adsorbed in the surfaces of these dilute solutions lie flat in the surface it is probable that τ is of the same order of magnitude as the values found for ricinoleic acid or triricinolein, namely, 4.7×10^{-8}.

The last column of Table III. gives the values of A calculated from B by an equation similar to (9) except that the numerical constant was 12·5 instead of 12·8, since the temperature in Traube's experiments were 15° instead of 20°.

It is seen that $\lambda_{obs.}$ increases on the average by about 625 calories for each CH_2 added to the molecule. This means that λ can be expressed in general by an equation of the form

$$\lambda_{cal.} = \lambda_0 + 625\, n \quad . \quad . \quad . \quad . \quad . \quad (30),$$

where n is the number of carbon atoms in the molecule. The quantity λ_0 has a different value for each type of substance, as is shown in Table IV.

TABLE IV.—*Values of* λ_0.

Type.	Formula	λ_0.
Tertiary alcohol..	R_3COH	950
Primary amine	RCH_2NH_2	600
Primary alcohol	RCH_2OH	575
Ester	$RCOOR'$	470
Monobasic acid..	$RCOOH$	437
Ketone	$RCOR'$	295
Aldehyde	$RCHO$	210
Amide	$RCONH_2$	—510
Dibasic acid (or alcohol)..	—	—700

When a double bond is present in the molecule the value of λ_0 is decreased by about 400. The addition of one or more hydroxyl groups to a mono- or dibasic acid decreases λ_0 by about 800 for each hydroxyl group.

The fifth column of Table III. gives values of λ_{cal} which have been calculated by Equation 30, using the values of λ_0 given in Table IV.

An examination of Table IV. shows that λ_0 becomes smaller as the active groups in the molecule become more polar in character. It also shows that the polar character *is not additive. Two active groups attached to adjacent* carbon atoms, as in glycol, caused a very great decrease in λ_0. Such effects, with which chemists are familiar, are undoubtedly due to forces transmitted from atom to atom in the group molecule. It is probable that these forces are caused by a displacement in the relative positions of the electrons and positive nuclei. Thus if an oxygen atom is combined with a carbon atom at one end of a hydrocarbon chain the electrons in the carbon atom are probably displaced towards the oxygen atom and the positive nucleus of the carbon atom displaced away from the oxygen atom. This displacement causes a similar but smaller displacement of the electrons of the next carbon atom and so on. (Effects of this kind are probably of importance not only in organic chemistry, but in the study of the structure of the surfaces of crystals and of liquids. In some cases such phenomena may cause adsorbed layers to be more than one group molecule in thickness).

The close agreement between the observed and calculated values of λ in Table III. shows that, except in the case of active groups in close proximity within the molecule, the change in potential energy λ between the interior and surface of the liquid is an additive property.

The results for a_s in Table III. are in substantial agreement with the results previously discussed. For the saturated acids, alcohols, and esters the values are approximately the same (30×10^{-16} sq. cm.) and are independent of the number of carbon atoms.

The presence of double bonds (allyl alcohol and acetate) does not seem to cause any increase in a_s, probably because these are forced away from the water before the surface becomes saturated. With oxy-butyric acid a_s is much greater (48×10^{-16}), indicating that the hydroxyl group is in contact with the water even when the surface is saturated. The large value for acetone (42·5) and the small value for butyl aldehyde (24·8) are noteworthy, but until verified by other data it would hardly be safe to draw conclusions from these differences.

There are many other data available from which the arrangements of group molecules in surface layers are determinable. Some of these will be briefly mentioned.

Morgan and Egloff (*Journ. Am. Chem. Soc.*, 1916, xxxviii., 844) give the surface tensions of solutions of phenol and water at three temperatures. From these data by Equation 1 the amounts of phenol adsorbed per sq. cm. (q) may be calculated.

It is found that with increasing concentration q increases, rapidly at first, then more slowly until it reaches a maximum of about 48×10^{-11} grm. molecules per sq. cm., showing that the surface becomes saturated with phenol molecules. This maximum value of q is approximately the same at all three temperatures (0°, 35°, and 65°), but at the higher temperatures it requires a greater concentration of phenol in the solution to give a saturated surface than at lower temperatures. This fact is a natural result of the kinetic agitation which tends to equalise the concentration in the surface and in the solution. From the above value of q it can be readily calculated that the area per molecule of adsorbed phenol is $a_0 = 34 \times 10^{16}$ and the thickness of the film is $\tau = 4.3 \times 10^{-8}$ cm. These results would seem to indicate that the phenol molecules in the surface of an aqueous solution lie flat on the surface, and that the diameter of the disk-shaped (assumed) molecule is about one and a half times its thickness.

Morgan and Egloff's data on triethylamine-water solutions show that the surface is saturated with this substance even with the most dilute solutions used (0·5 per cent). The values of q were fairly constant $q = 40 \times 10^{-11}$ and were the same at 0° as at 30°. This result corresponds to—

$$a_0 = 41 \times 10^{-16} \text{ sq. cm.}$$
$$\tau = 5.6 \times 10^{-8} \text{ c.m.}$$

It is probable from these results that the three ethyl groups lie spread out upon the surface while the nitrogen atom is below the surface and is surrounded by water molecules combined with it by secondary valence.

Worley (*Journ. Chem. Soc.*, *1914*, *cv.*, *260*) *gives data* for aqueous solutions of aniline at several temperatures from 15° to 75°. The values of q calculated from (1) show a variation quite similar to that found from the data on phenol-water solutions. The surface becomes saturated more easily at low than at high temperatures. The data are apparently not as accurate as those of Morgan and Egloff, but they indicate a fairly constant saturation value of $q_s = 45 \times 10^{-11}$. This corresponds to—

$$a_0 = 37 \times 10^{-16} \text{ sq. cm.}$$
$$\tau = 4.0 \times 10^{-8} \text{ cm.}$$

Evidently the arrangement of the aniline molecules in the saturated surface is about the same as that of the phenol molecules.

We have thus far considered cases where the solute is adsorbed in the surface layer, so that the surface tension is less than that of the pure solvent. When inorganic salts are dissolved in water or alcohol the surface tension increases. The surface of the solution thus contains an excess of the solvent. In general we should expect the surface of any liquid to consist of molecules or atoms arranged in a rather definite manner different from that in the interior. If the molecules or atoms of the dissolved substance are surrounded by fields of force strong compared to those of the solvent, then it is improbable that the solute molecules will be able to displace solvent molecules in the surface. Hence the surface layer should consist of a single layer of molecules of the solvent from which solute molecules are excluded.

From Gibbs' Equation 1 we see that if the surface tension *increases* linearly with the concentration, there is a *deficiency* of the solute in the surface layer which is pro-

portional to the concentration. Now this is exactly what we should expect if the surface layer consists of pure solvent. Let τ be the thickness of this layer. Then q the deficiency of solute per sq. cm. of surface is—

$$q = \frac{\tau c}{1000}$$

or by (1)—

$$\tau = 1000 \frac{-q}{c} = \frac{1000}{RT} \frac{d\gamma}{dc} \quad . \quad . \quad . \quad . \quad (31).$$

We can thus calculate τ the thickness of a single layer of molecules of the solvent by measuring the increase of surface tension produced by the addition of a soluble salt.

Unfortunately the data for $d\gamma/dc$ for aqueous salt solutions are rather variable. Thus for potassium chloride solutions different observers have found results given in Table V.

TABLE V.

Observer	$d\gamma/dc$	τ cm	a sq. cm
Forch (*a*)	1·41	3·3 × 10^{-8}	9·0 × 10^{-16}
Whatmough (*b*) ..	1·81	4·24 "	7·02 "
Linebarger (*c*) ..	1·75	4·1 "	7·26 "
Quincke (*d*).. ..	1·747	4·1 "	7·27 "
Volkman (*e*) ..	1·56	3·66 "	8·15 "
Rother (*f*).. ..	1·63	3·83 "	7·80 "

(*a*) *Ann. Phys.*, 1905 (4), xvii., 744.
(*b*) *Z. Physik. Chem.*, 1901, xxxix., 154.
(*c*) *Journ. Am. Chem. Soc.*, 1899, xxi., 413.
(*d*) *Ann. Phys.* (2), clx., 337, 560.
(*e*) *Ibid.*, (3), xi., 177; 1881, xvii., 353.
(*f*) *Ibid.*, 1884 (3), xxi., 576.

The values of τ were calculated from Gibbs' equation by (31), taking into account the electrolytic dissociation of the potassium chloride solution. This is best done by using Lovelace, Frazer, and Miller's data (*Journ. Am. Chem. Soc.*, 1916, xxxviii., 515) on the vapour pressure of potassium chloride solutions and then applying Gibbs' equation in the form—

$$q = \frac{-p}{RT} \frac{d\gamma}{dp} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (32),$$

where p is the vapour pressure of the solution. By substituting values of q obtained in this way into (31) the values of τ given in Table V. were found.

From these results it may be concluded that the layer of pure water adsorbed in the surface of a potassium chloride solution is about 4×10^{-8} cm. thick. This probably represents the length of the water molecules in the surface, so that their cross-section (assuming H_2O as the group molecule) is about $7·4 \times 10^{-16}$ sq. cm.

It is interesting to note that the results obtained with other salts are in substantial agreement with the above. Although different salts give different values of $d\gamma/dc$, these differences seem to be almost wholly accounted for by differences in the degree of electrolytic dissociation.

Cederberg (*Journ. Chim. Phys.*, 1911, ix., 10) finds for solutions of sodium iodide in ethyl alcohol $d\gamma/dc = 1·09$. This leads to $\tau = 4·4 \times 10^{-8}$ cm. and $a = 22· \times 10^{-16}$ sq. cm. for the adsorbed layer of pure alcohol in the surface of this solution.

Gibbs' equation may also be applied to cases where the surface tension of a liquid is decreased by the presence of a vapour above the liquid. For example, benzol or hexane vapours brought into contact with the water decrease the surface tension of the water very markedly. By measuring the surface tension as a function of the partial pressure of the vapour up to pressures sufficient to yield a saturated adsorbed film, it must be possible to obtain very definite information as to the shapes and arrangements of these hydrocarbon molecules. Experiments of this kind were begun in this laboratory, but owing to the present unsettled conditions have been discontinued.

(To be continued).

THE NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES, HELD IN NEW YORK.*

By THOMAS H. NORTON, Ph.D., Sc.D.

(Continued from p. 8).

The Dow Chemical Co., Midland, Mich.

The exhibit of the many chemicals made by this company was extensive and impressive. The factory plant includes 260 buildings, and ranks among the most important of the country. Chief interest centred about the synthetic indigo, which is now being produced at the rate of nearly 2000 pounds of 20 per cent paste daily. The daily output will gradually be increased to 5000 pounds. Much of the product is transformed regularly into dibromo-indigo, which yields the most satisfactory results in cotton dyeing. Imports of the dibromo derivative from Europe were increasing prior to the war, and it is the feeling of the company that there is a large field for this compound. Prominent among the other coal-tar derivatives exhibited by the Dow Co., were synthetic phenol, salicylic acid, acetylsalicylic acid, methyl salicylate, ethyl salicylate, benzoic acid, sodium benzoate, sodium benzene-sulphonate, bromo-benzene, chloro-benzene, *o*-dichloro-benzene, *p*-dichloro-benzene, dinitro-phenol, and tribromo-phenol. The acetic anhydride now produced by this company is of great importance to the synthetic colour industry.

The Chemical Co. of America, New York.

The works of this company at Springfield, N.J., have become a leading centre for the manufacture of coal-tar intermediates. Starting out early in 1915 with the production of aniline on a large scale, it has steadily enlarged the scope of its operations until it now furnis: es most of the important intermediates. The following were exhibited:—Acet-chlor-aniline, acet-toluide, amido-azo-toluol, aniline, aniline oil for red, anthranilic acid, Bayer's acid, benzaldehyde, benzidine base and sulphate, benzoyl chloride, benzyl chloride, chlor-aniline, chromotropic acid, diacetyl paramidophenol, dianisidine, diethylaniline, dimethylaniline, dinitrobenzol, dinitrochlorbenzol, dinitrophenol, dinitrotoluol, γ-acid, G salt, metanitraniline, metanitroparatoluidine, metaphenylenediamine, metatoluylendiaminol, monoethylaniline, naphtionic acid, nitro-benzol, nitro-toluol, ortho-nitro-chlorbenzol, ortho-nitro-para-toluidine, ortho-nitro-phenol, ortho-nitro-toluol, ortho-toluidine, para-amido-acetanilid, paramidophenol, paranitracetanilide, para-nitro-chlorbenzol, para-nitro-phenol, paranitrotoluol, paraphenylenediamine, para-toluidine, R salt, Schaffer's salt, sulphanilic acid, tetra-methyl-diphenylmethan, tolidine base and sulphate, toluidine, xylidine. The company has not yet taken up actively the manufacture of colours, but is making plans to enter this field at an early date.

The Seydel Manufacturing Co., Jersey City.

The company has undertaken the manufacture of benzoic acid upon a large scale, the annual output being 150 short tons. In its exhibit were the acid itself, and the leading derivatives, sodium benzoate, β-naphthol benzoate, methyl benzoate, and ethyl benzoate. Other products were benzyl alcohol, benzaldehyde, nitrobenzene, nigrosine, furamine (for dyeing furs), and a variety of sizings for textiles.

Newport Chemical Works, Inc., Carrollville, Wis.

This company is one of the few in the west engaged in the manufacture of coal-tar products. It utilises the crudes supplied by the coke-ovens of the Milwaukee Coke and Gas Co., and of the North-Eastern Iron Co. It exhibited the various crudes, including phenol and pyridine, in a refined form, and the following intermediates:—α-naphthylamine, nitro naphthalene, di-nitro naphthalene,

* From the *Chemical Engineer*, October, 1917.

ortho-nitro toluol, para-nitro toluol, ortho-toluidine, para-toluidine, tolidine, 1 : 3 · 6 acid, H acid.

E. I. du Pont de Nemours Co., Wilmington, Del.

There was a diversified exhibit of fabrikoid and other products made by this company, apart from its main purpose of manufacturing munitions. The display of benzene, toluene, naphthalene, nitrobenzene, and dimethylaniline was limited to the raw materials which will serve in the extensive plans of the company to enter upon the production of dye stuffs.

The Calco Chemical Co., Bound Brook, N.J.

A very effective display of intermediates, including nitrobenzol, aniline oil, aniline salt, dimethylaniline, *dinitro-benzol, metaphenylenediamine, β-naphthol*, sulphanilic acid, naphthionic acid, nitro-xylol, xylidine, and paranitraniline. The dyes regularly manufactured are :—Acid colours — scarlet 2R, scarlet 2RX, orange II., Bordeaux B, crimson Y, Bordeaux 2BX, tartazine. Chrome colours—yellow, orange, green, brown. Basic colours—methylene blue, methyl violet. Direct colours—orange R, maroon red, red, chrysamine, violet R. Lake colours—lake scarlet 2R, lake scarlet 2RX, acid orange, Bordeaux B, methylene blue, methyl violet. All of the dye-stuffs were shown in solution. The sample dyeings were grouped together in a fan-shaped design, in front of which was an enormous cube of β-naphthol. The whole arrangement was very effective.

The Williamsburg Chemical Co., Inc., Brooklyn.

The exhibit included the following intermediates :—Benzylchloride, benzalchloride, benzaldehyde, benzoic acid, U.S.P., benzoate of soda, U.S.P., and dinitrochlorbenzol. But three dye-stuffs are made by the company :—Sulphur black, malachite green, and auramine. These were accompanied by sample dyeings. The whole display was very tastefully arranged.

New Jersey Products, Inc., Silver Lake, N.J.

Under this new designation appeared the products of the Thomas A. Edison Affiliated Companies. They were :—Benzol, toluol, xylol, solvent naphtha, naphthalene, phenol, aniline oil, aniline salt, acetanilide, paraphenylenediamine, para-amidophenol base, para-amidophenol, hydrochloride, para-nitroacetanilide, benzidine, benzidine sulphate, acetyl-para-phenylenediamine. The coal-tar products made by the Edison companies are not many in number, but are manufactured upon a very large scale. Mr. Edison was one of the first, in 1915, to produce synthetic phenol and aniline in great quantities. He has limited subsequent expansion to a few important derivatives of these substances, notably para-phenylenediamine and para-amidophenol. Aniline is no longer produced for the market. The output of synthetic phenol continues, however, to be very large, and it is the intention to continue this feature indefinitely after the return to normal conditions, even in competition with phenol secured directly from coal-tar. Both phenol and para-phenylene diamine are employed to quite an extent in the manufacture of records for phonographs and gramophones conducted by the Edison Co.

Butterworth-Judson Corporation, Newark, N.J.

A most imposing display was made by this company of the great variety of general chemicals manufactured in its extensive works. It is but recently that it has entered the field of coal-tar compounds. The list of intermediates now currently produced is, however, long and varied. The exhibit contained :—Nitro-benzol, di-nitro-benzol, *meta- and para-phenylene-diamine, benzidine* sulphate, benzidine base, nitro-naphthalene, di-nitro-naphthalene, α-naphthylamine, naphthionic acid, ethyl-α-naphthylamine, methyl-α-naphthylamine, diphenylamine, H acid, γ-acid, Neville and Winther acid, Schaeffer's acid, Cleve's acid, β-naphthylamine, para-nitraniline, meta-nitraniline, para-nitrophenol picramic acid, mono- and di-sulphonic acids, R acid, G salt, di-amino-tetra-methyl-benzophenone, *di-amino-tetra-methyl-benzhydrol, benzal chloride, benzyl* chloride, benzotrichloride, salicylic acid, salicylate of soda, methyl salicylate, phthalic anhydride, dimethylaniline. No colours were shown except Victoria blue and crystal violet. The company is now making phosgene and acetic anhydride on a large scale, especially for use in the manufacture of coal-tar dyes.

The Radcliffe Colour and Chemical Works, Elizabeth, N.J.

Nigrosine is the chief product made at present. It was shown in all the standard forms, in blue, blue-black, and jet-black shades, and oil, spirit, and water soluble varieties.

The American Synthetic Colour Co., Stamford, Conn.

The efforts of this company are now concentrated chiefly on intermediates. The products shown were :—Picric acid, *o*-nitro-phenol, *p*-nitro-chloro-benzene, *p*-nitro-phenol, and dinitro-chloro-benzene. The latter is the main element in the current output, and is supplied to manufacturers of sulphur-black. The company is now producing large quantities of sodium nitrite, for the use of dyers and manufacturers of azo colours.

Empire Chemical Co., New Brunswick, N.J.

The activities of the company are devoted chiefly to intermediates. Its exhibit contained :—Nitrobenzene, aniline, *p*-nitraniline, *o*-toluidine, *p*-toluidine, *m*-nitro-*p*-toluidine, *p*-nitro-*o*-toluidine, *p*-amido-phenol, and *p*-nitro-chloro-benzene. In addition there were various nigrosines.

King Chemical Co., Bound Brook, N.J.

The company displayed sulphur-blue, sulphur-black, methylene-blue, and primuline, accompanied by various direct reds, pinks, oranges, and yellows. There was a good collection of sample dyeings.

Hellenic Chemical and Colour Co., New York.

The dyes made by this company are methyl violet, methylene blue, Bismarck brown, nigrosines, eosine, fuchsine, malachite green, and victoria blue. It specialises also in lakes and dry colours, and showed in this collection toluidine-red toner, para-red and para toner, phloxine lake and phloxine toner, magenta lake, rose lake, and madder lake.

Dye Products and Chemical Co., Newark, N.J.

The company made a very creditable exhibit of intermediates and finished dye stuffs. The former included nitro-toluol, dinitro-toluol, meta-toluylene-diamine, di-amine-developer C (crystals), toluidine, aniline, and para-phenylene-diamine.

The chief colours represented were :—Naphthol green, Newark-scarlet, ponceau-scarlet, acid-yellow, chrome blue-black, chrome brown, copper-purple, chrysoidine, eosin, and Bismarck brown.

Madero Bros., New York.

This firm, while not manufacturing, is doing a large business as a distributor of chemicals, and especially of dye-stuffs. It is rendering excellent service in building up foreign markets for our chemical products. It presented an excellent display of intermediates and of colours, including some made by the Monroe Drug Co., of Quincy, Ill.—notably H acid.

Frank Hemingway, Inc., New York.

This company is also devoted largely to the distribution and export of chemicals and dye-stuffs. It has, however,

entered the field of coal-tar products, and manufactures on a large scale Michler's ketone, and various dyes made by its aid. The following colours were exhibited:—Victoria blue B, victoria blue R, victoria blue 4R, crystal violet malachite green, Bismarck brown, primuline, safranine, para-nitraniline, methylene blue. Attractive charts, with coloured ribbons, outlined the genesis of each dye from coal-tar crudes.

Fifty intermediates were shown, among which were α-naphthol, α-naphthylamine, aniline, Bayer acid, benzidine, base and sulphate, benzaldehyde, benzyl chloride, β naphthol, β-naphthylamine, Broenner's acid, dimethylaniline, dinitrobenzene, dinitronaphthalene, dinitrophenol, dinitrotoluene, diphenylamine, γ-acid 2:6:8), H acid (1:8:3:6), metaphenylenediamine, Michler's hydrol, Michler's ketone, naphthionic acid, Neville and Winther's acid, ortho-nitro-phenol, ortho-toluidine, para-amidophenol, para-dichlorobenzene, para nitro phenol, paraphenylenediamine, para-toluidine, phenylalphanaphthylamine, phthalic anhydride, picramic, resorcin, R salt (2:3:6), salicylic acid, Schaeffer's acid, sulphanilic acid, tetranitromethylaniline, and xylidine.

A. Klipstein and Co., New York.

The exhibit of this long established firm included numerous chemicals for the use of the dyer and tanner. Of especial interest were the sulphur dyes now made in quantity at Chrome, N.J., by the E. C. Klipstein and Sons Co. They embraced blacks, blues, yellows, browns, and khaki tints. The zeta black is in demand for hosiery. Vat blues and indigo extract of this company are in extended use. An interesting feature was the collection of ciba colours and other coal-tar dyes, the products of the Basle Society of Chemical Industry, which the firm has imported regularly from Switzerland during the war, and which have done much to lessen the acuteness of the dye-stuff shortage.

Geisenheimer and Co., New York.

This well known importing and jobbing firm displayed a great variety of artificial colours, mostly from American works for which it is the selling agent. The most interesting feature of this extensive exhibit was the collection of dyes now made currently by the Ault and Wiborg Co., of Cincinnati, O. This company is one of the largest, if not the largest, producers of inks in the world. It requires normally very considerable amounts of a few staple shades. When cut off from European sources of supply in 1915, it promptly erected large works to furnish an adequate supply for its regular needs. The results were so successful that the output was notably enlarged both in quantity and variety. The colours exhibited were the following pigments:—Ambrose red, liberty toner and liberty red, all in various shades, and the following dyes: Alizarin orange W, alizarin yellow GGW, chrome bordeaux, cloth red GO, acid bordeaux, acid orange No. 2, amaranth, azo crimson, brilliant acid orange G, croceine 3BX, fast red A, induline NN, metanil yellow, ponceau G[illegible], scarlet RR, tartrazine conc, eosin, erythrosin, meldola blue, and Bismarck brown R and Y.

The following intermediates, manufactured by Ault and Wiborg, were also shown:—Amido-azo-toluol hydrochloride, amido-azo-benzol-hydrochloride, α-naphthylamine, α-naphthylamine-hydrochloride, α-nitro-naphthalene, aniline oil, aniline salt, Bayer salt 2:8, Broenner acid 2:6, β-naphthylamine, β-naphthol, dinitro-benzol, dinitro-chloro-benzol, dinitro-toluol, monosulphonic acid F 2:7, nitro-benzol, nitro-ortho-chlor-benzol, naphthionic acid 1:4, Neville-Winther acid, ortho-toluidine, paratoluidine, paranitraniline, para-amido acetanilide, para-nitro-chlor-benzol, phenyl-α-naphthylamine, R salt 2:3:6, Schaeffer salt 2:6, sodium naphthalene-β-sulphonate, sulphanilic acid, tetra-methyl-diamino-diphenyl-methane, and xylidine.

(To be continued).

THE PATENTS AND DESIGNS BILL.

Its Provisions and Purpose.

This Bill, which was presented to the House of Commons by Sir Albert Stanley on November 19 last, seeks to amend the Patents and Designs Act, 1907, in the light of the experience gained from working the existing Act and also the Temporary Rules for which authority was given by Parliament in 1914. Under the Patents, Designs, and Trade Marks (Temporary Rules) Acts licences have been granted for the working of enemy-owned patents and designs, and permission given to use enemy trade marks, and considerable information has been thus obtained as to the effect of our Patent and Trade Marks law on business undertakings, and in particular on those under foreign control. In view of this experience it appeared to the Board of Trade necessary that the principal Act of 1907 relating to patents should be amended in several important particulars. The whole question was considered from the commercial point of view by a Sub-Committee of the Advisory Committee on Commercial Intelligence, and the Board of Trade had also the advantage of the advice of a special Committee under the Presidency of Lord Parker containing representatives of the legal profession, inventors, and practising Patent Agents. The Bill is the result of their efforts.

A patent to an inventor is the grant of a temporary monopoly which serves the double purpose of enabling the inventor to secure the support of capital to develop and work his invention, and of giving to the public and trade generally the benefit of new discoveries. Human brains need the stimulus of human ambition to make money and get on in life, if the community is to get full value from their exercise. The inventor must, therefore, be encouraged and rewarded so that he may exercise his skill, and those with capital who desire to assist him must be afforded protection in their enterprise. But since monopolies are liable to abuse, the State must endeavour to make sure that no monopoly granted to a private person by the Crown shall be wrongly used to the detriment of national trade or of national interests generally.

Abuses of the Patent Monopoly.

The new Bill aims at preventing—or at least of making very difficult—the chief abuses to which patent monopolies are subject. First, an inventor may from ulterior motives try to prevent the use altogether of the patented invention within the United Kingdom. Secondly, an inventor may be a foreigner who wishes to manufacture the invention in his own country and to export the products to Great Britain, which would meanwhile be prevented by him from manufacturing the products itself; this would be to encourage trade abroad and hamper it in Great Britain. Thirdly, while not going so far as to try to prevent the use of the manufacture of an invention in this country, an inventor may, in fact, restrict British trade by keeping the invention entirely in his own hands and unreasonably refusing to grant licences for its manufacture by others. It is in the interests of our National trade that these abuses of the grants of patents should be stopped, and that every encouragement should be given for the early manufacture within this country of promising inventions. The Act of 1907 sought to effect these purposes; what the new Bill does is to provide a complete and comprehensive scheme and to make good the discovered defects in the existing Act.

Compulsory Licences and Revocation.

Clauses 1 and 2 of the new Bill are in substitution of Section 27 (Revocation of Patents worked outside the United Kingdom) and Section 24 (Compulsory Licences and Revocation) of the Act of 1907. It was found that the procedure under Section 24 was cumbrous and expensive and had been rarely used. And as regards Section 27 the standard of comparison between British and foreign manufacture was one which has been difficult to work out

in practice owing to the absence of the necessary data. It is therefore proposed in Clause 1 of the Bill to amalgamate these two Sections of the Act of 1907 and to replace them by one clause. Simplicity and inexpensiveness are aimed at. Clause 1 provides that any abuse of his patent rights by the patentee—either by failure to work his patent or to grant licences on reasonable terms whenever the public interest demands, or by unfair conditions imposed on the use or sale of the patented article—will render him liable to have his patent revoked, or a compulsory licence granted on reasonable terms whenever the latter course appears to be the fairer or more appropriate remedy. In comparison with Section 24 of the existing Act the procedure for obtaining licences has been greatly simplified and the grounds for applications for licences much enlarged and made more definite. Application is in the first instance to be made to the Comptroller with an appeal to the Court. The intention is to provide adequately against a patent being hung up. The provisions of the Clause do not operate until after the expiry of four years in the life of a patent, and this period of freedom may be extended if the Comptroller judges that the time which has elapsed has been insufficient to enable the invention to be worked within the United Kingdom on a commercial scale.

The Two Main Classes of Inventions.

Inventions may be roughly divided into two classes: those which do and those which do not require for their development large amounts of capital. A small patented article of general utility, cheaply made and put on sale, may become profitable quickly and at little initial cost. On the other hand a machine, ultimately of great importance and value, may absorb £100,000 in capital and several years in time before the patentee or capitalist reaps the fruit of his enterprise. In the new Bill Clauses 1 and 2 are framed so that the tribunal—the Comptroller, the Court (on appeal), or in cases of agreement an arbitrator—may exercise adequate discrimination in deciding whether in any particular case there has been abuse of the patent monopoly. Revocation of a patent is not always, or even most often, the best course to adopt in the public interest. In very many cases the grant of compulsory licences is the most effective remedy and will secure the working in the United Kingdom of the patent. Suppose, for example, a foreign patentee wanted to prevent his patent from being worked in this country: if compulsory licences were granted to manufacturers here then the patent would be worked and British trade be benefitted; but if it were revoked altogether then the foreign patentee might secure a practical monopoly, in spite of this revocation, by importing the article from abroad on terms making British competition practically impossible without the assistance of the Patent monopoly by which the holder of a compulsory licence would be protected.

A "Licence Patent."

Clause 2, which is substituted for Section 24 of the Act of 1907, proposes that the patentee should be allowed to declare his patent to be a "licence patent" and to have it endorsed with the words "licences of right." In that event anyone who wishes may claim a licence under it as a right. This provision is intended to encourage the commercial working of inventions, and to be of possible assistance to inventors who have no means of exploiting their inventions themselves or of coming into contact with those who wish to use the invention commercially. In default of agreement the terms of the licence are to be settled by the Comptroller or the Court. Care will be taken when framing the rules to carry out the provisions of this Clause, that a patentee does not evade the possibility of the revocation of his patent by converting it into a "licence patent."

Oppositions to Grant of Patents.

It has been frequently represented to the Patent Office that the present search through British specifications of the preceding fifty years is insufficient and that an attempt should be made to make the search universal. The experience of other countries, which profess to make a universal search, suggests that so catholic and ideal an aim is not possible of attainment in practice. It is, however, felt that in order to guard against the grant of invalid patents certain grounds of opposition might usefully be allowed in addition to those provided under Section 11 of the Act of 1907. Clause 4 of the new Bill provides that opposition to a patent may be filed—(1) on the ground that the invention has been published in any printed document before the date of application for a patent; and (2) in the case of applications under the International Convention, when the invention described in the application filed in this country differs from that described in the specification filed in the country of origin, and when the additional matter forms the subject of an application made by the opponent in the interval between the deposit of the application in the foreign State and the deposit of the application in this country. The remainder of Clause 4 consists of re-drafting made necessary by these proposed amendments.

Assignments of Patent Rights.

Clause 5 amends Section 12 of the Act of 1907 relating to the grant and sealing of patents. It provides a remedy for a breach of agreement by an applicant who has undertaken in writing to assign the patent, when granted, to another person or joint-applicant, but who refuses to proceed with the application. In such an event the patent application may, under the new Clause 5, go forward at the request of the person to whom the invention has been assigned when the original inventor declines to carry out his agreement.

The Term of Patents: Extension.

The present duration of a patent is fourteen years from the date of the original application. The term is less than has been adopted by most other countries signatory to the International Convention. It has been frequently urged by other countries—and among them our principal Allies—that we should extend our term of fourteen years. Inventors generally have supported this request. It has been felt by those responsible for the new Bill that opportunity should be taken now for extending the term of British patents to fifteen years at least. The Bill, by Clause 6, grants the term of fifteen years, and gives power by Order in Council for a further extension to sixteen years should this extension become expedient—in view of any conventions with foreign countries. It is important to note that the proposed extension under Clause 6 is granted to all patents in force when the Bill becomes an Act, and not only to new patents.

The Suggested War Extension.

The point which has just been mentioned has an important bearing on Clause 7 dealing with the power of the Court to extend for special reasons the term of a patent beyond the date of its normal expiry. At present if, after enquiry, the Court finds that a patentee has not been adequately remunerated by his patent—if, for example, it has been an important and worthy machine, or process, that has taken several years to develop before becoming revenue earning—the Court has power to extend the patent for seven years and even, in very exceptional cases, for fourteen years. The War has introduced a new factor, and it has been urged on the part of inventors that the term of all existing patents should be extended automatically for the period of the war. The Board of Trade did not feel able to recommend this general war extension of all patents, as it would not discriminate between those inventors who had made large war profits —as many of them have done—and those who have suffered losses. General war-period extension of patents cannot be defended. What the new Bill proposes to do is to provide for an extension in the case of those inventors

who can establish a just claim to it. Power is given to the Court under Clause 7 to extend the patent term of those patentees who can prove that loss has been due to hostilities. Patentees who are subjects of enemy States are excluded from benefits of this Clause. In view of the general extension of patent terms by one or two years under Clause 6 of the Bill the period of extension within the discretion of the Court is reduced. Instead of being, as at present, for seven and, in exceptional cases, fourteen years, it becomes under the new Bill for six and twelve years respectively.

The remaining Clauses of the new Patents Bill which aim at reducing the cost and rendering more simple the trials of patents actions, and those Clauses which deal with the grant of patents for articles of food and drugs, the registration of designs, the compulsory registration of assignment of patents and designs, the registration of patent agents and certain minor amendments to the Act of 1907 will be described and explained in a second article to be published next week.—*The Board of Trade Journal*, 1911, c., 4.

TEN YEARS OF AGRICULTURE THROUGHOUT THE WORLD.*

In dealing with the statistics of agriculture, even more particularly than in reviewing those relating to other matters, the wide variety of crops, of climate, of terms employed, makes it exceedingly difficult to draw up any estimates of production that are beyond cavil. In the course of the nineteenth century many efforts were made to accomplish this aim, but in order to reach a practical and tangible result it became necessary to create a central organisation of high standing, specially arranged for the collection and scientific classification of the very miscellaneous data which are published in so many parts of the world. This central organisation is the International Institute of Agriculture of Rome, so well known to competent authorities by its numerous publications, and this Institute has just issued a new work dealing on a very complete and accurate basis with the world's agriculture.

This volume is the "International Year-book of Agricultural Statistics 1907 to 1916," and is without any doubt the most complete work in existence on agricultural statistics, as it is the result of the most extensive and, at the same time, the most detailed research yet devoted to this study.

Comprising over one thousand pages, the 836 statistical tables are replete with every sort of information upon the subjects considered, thus establishing the volume as one of the highest importance.

The number of agricultural products embraced is very large, and those of tropical countries have received as much attention as the crops of the temperate zones have secured.

In due sequence are furnished all the available data regarding areas cultivated in each country, the total yields realised, and the yields obtained on a given standard of area. Besides all this the Year-book includes the five years' and ten years' averages for the period included, so that readers can ascertain at a glance whether in any particular year cultivation has extended or has been restricted in a given country and whether the results have been favourable or the reverse.

The first products to be considered are the cereals, as naturally being of capital importance for food, the very basis of human requirements inasmuch as they furnish our daily bread.

We find that the ascertainable annual yield of wheat throughout the world exceeds a thousand million quintals, and represents at present values more than two thousand millions sterling; the yield of maize is nearly as large as that of wheat, and is worth one thousand millions sterling, while the aggregate value of the six chief cereals (wheat, rye, barley, oats, maize, and rice) is not less than six thousand millions sterlings, or thirty billions of dollars, yearly.

The yield of potatoes is over fifteen hundred million quintals, and that of sugar beet is more than five hundred million quintals. Every year the world has at disposal a total of 150 million quintals of beet and cane sugar, nearly 150 million hectolitres of wine, ten million quintals of coffee, more than eight millions of leaf tobacco, nearly one million quintals of hops.

Textile industries account annually for nearly fifty million quintals of cotton, eight millions of flax, seven millions of hemp, while silkworm breeders in Europe and Asia deliver to the trade more than 200 millions in cocoons. The raw material for vegetable oils comprises yearly throughout the world an aggregate of thirty million quintals of olives, and a similar quantity of linseed, four millions of hempseed, and five millions of rapeseed.

* International Institute of Agriculture, Bureau of General Statistics.

ORDERS OF THE MINISTER OF MUNITIONS.

Ministry of Munition of War,
Whitehall Place, S.W. 1
December 31, 1917.

TAR.

The Minister of Munitions in exercise of the powers conferred upon him by the Defence of the Realm Regulations and of all other powers enabling him hereby orders as follows:—

1. For the purposes of this Order the expression "coal-tar" shall mean tar produced or derived from the destructive distillation of bituminous material by any means other than blast furnaces, the expression "water-gas-tar" shall mean tar produced by carburetting water-gas, and the expression "tar" shall mean and include both coal-tar and water-gas-tar as above defined.

2. No person shall as and from the day following the date of this Order until further notice purchase or offer to purchase any tar (whether crude or dehydrated) except under and in accordance with the terms and conditions of a Licence issued by or under the authority of the Minister of Munitions. Provided that no licence shall be required—

(a) By a tar distiller for the purchase of tar in any quantities, provided that the whole quantity purchased is intended to be and is in fact distilled to pitch by such distiller.

(b) By any person for the purchase of tar (whether crude or dehydrated) in quantities not exceeding ten gallons provided that the total quantity purchased by any one person during any one calendar month does not exceed 50 gallons.

3. No person shall as from the day following the date of this Order until further notice except under and in accordance with the terms and conditions of a Licence issued by or onder the authority of the Minister of Munitions—

(i.) Accept delivery of or make payment for any coal-tar tendered for delivery under any coutract existing at the date of this Order unless (a) such contract was entered into prior to September 5 1917, and is in writing, and (b) full written particulars of such contract were furnished to the Minister of Munitions before October 1, 1917, by the person entitled at that date to deliveries thereunder; or

(ii.) Accept delivery of or make payment for any water-gas-tar tendered for delivery under any contract existing at the date of this Order unless (a) such contract is in writing and (b) full written particulars of such contract shall be furnished to the Minister of Munitions before January 25, 1918, by the person for the time being entitled to deliveries thereunder.

4. As on and from January 15, 1918, until further notice no person manufacturing or producing tar shall burn or consume any such tar for firing, steam raising, or heating purposes, nor use any such tar for any other purpose except under and in accordance with the terms and conditions of a licence issued by or under the authority of the Minister of Munitions. Provided that no such licence shall be required by a manufacturer or producer of tar who is also a tar distiller to entitle him to distil to pitch all or any of the tar manufactured or produced by him.

5. The Order of the Minister of Munitions dated September 4, 1917, relating to coal-tar is hereby cancelled, but such cancellation shall not affect the previous operation of that Order nor the validity of any action taken thereunder, nor the liability to any penalty or punishment in respect of any contravention or failure to comply with such Order prior to this cancellation nor any proceeding or remedy in respect of such penalty or punishment.

6. This Order may be cited as the "Tar (Coal and Water-gas) Order, 1917."

CRUDE SOLVENT NAPHTHA, SOLVENT NAPHTHA, AND HEAVY NAPHTHA.

The Minister of Munitions in exercise of the powers conferred upon him by the Defence of the Realm Regulations, and of all other powers enabling him hereby Orders as follows:—

1. No person shall as from January 10, 1918, until further notice supply to any person, or take, or accept, or attempt to obtain delivery of any crude solvent naphtha, solvent naphtha, or heavy naphtha, except under and in accordance with the terms and conditions of a licence issued by or under the authority of the Minister of Munitions.

2. All persons engaged in producing, treating, distributing, storing, selling, or dealing in crude solvent naphtha, solvent naphtha, or heavy naphtha, or in any manufacture, trade, or business in which the same or any of them are used, shall make all such returns with regard to their businesses and verify the same in such manner (including production of their books) as may from time to time be required by or under the authority of the Minister of Munitions.

3. For all purposes of this Order the expressions "crude solvent naphtha," "solvent naphtha," and "heavy naphtha" shall mean crude solvent naphtha, solvent naphtha, and heavy naphtha obtained during distillation of coal-tar or extracted from coal-gas.

4. This Order may be cited as the Naphtha Order, 1917.

NOTE.—All applications in reference to this Order, including application for licences, should be addressed to the Director of Raw Materials Supply, Ministry of Munitions, Department of Explosives Supply, Storey's Gate, Westminster, S.W. 1.

CORRESPONDENCE.

PARAFFINOID MATTER IN PEAT.

To the Editor of the Chemical News.

SIR,—The presence of a solid paraffin in black peat is now well known. I may just mention that about the year 1869 Dr. Angus Smith asked me to extract a portion of Scotch black peat with benzene. The dried substance yielded about 4 per cent of a deep brown paraffin. I recollect Dr. Smith remarking that possibly liquid paraffin might accompany the water underlying the peat, when the latter rested in a rock basin.

These remarks of mine are suggested by the discovery of mineral oil at Ramsey, Hunts, on Christmas Day.—I am, &c.,

P. H.

CHEMISTS FOR THE ARMY.

To the Editor of the Chemical News.

SIR,—May I ask for a few lines in your valuable paper about a problem which is no doubt puzzling many young chemists to-day. We have joined the army with a desire to take a more active part in the war than as a junior chemist in a munition works. After taking the ordinary examinations at a secondary school we have continued our education in chemistry and metallurgy at night classes, working in the laboratory of a steel works during the day. What will become of us after the war? Shall we be given a chance to catch up our interrupted studies?

Hoping I have not taken too great a liberty.—I am, &c.,

DURATION.

NOTICES OF BOOKS.

Trattato di Chimica Generale ed Applicata all' Industria. Vol. I. *Chimica Inorganica.* ("Treatise on General Chemistry and Chemistry Applied to Industry. Vol. I. Inorganic Chemistry"). By Dott. ETTORE MOLINARI. Fourth Edition, Part I. Milan: Ulrico Hoepli. 1918. Pp. xiv + 560. Price L. 12.50.

THIS well-known text-book has been thoroughly revised, and the fourth edition contains a large amount of new material. It gives a very comprehensive survey of applied inorganic chemistry, and may certainly be regarded as the standard work on the subject in the Italian language. The first part of Volume I. deals with the theories of chemistry, and the laws of physical chemistry are particularly fully and clearly treated, their application in processes of commercial importance being always kept in view. In the second section of the book the properties, preparation, and uses of the metalloids are discussed in detail. Industrial methods of preparation are described, as well as those ordinarily employed in the laboratory, and some processes of historic importance are included. Full statistics of production and consumption are given, and no important substances have been omitted.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

NOTE.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxv., No. 16, October 15, 1917.

Refractory Properties of Magnesia.—H. Le Chatelier and B. Bogitch.—Pure magnesia fuses at about 2400°, but the magnesia used for making bricks is never pure; it contains varying proportions of oxide of iron which colours it brown, and also some silica and alumina. All these impurities increase its fusibility. The authors have compared commercial bricks with those made of pure silica, measuring the resistance to crushing at various temperatures. All the bricks showed a sudden fall of resistance to crushing at a temperature depending upon their degree of purity, and it is for this reason that magnesia bricks are less satisfactory in furnace works than silica bricks, although their fusing-points, when they are not subjected to mechanical forces, are very considerably higher.

No. 17, October 22, 1917.

Transformation of Secondary and Tertiary Fatty Amines into Nitriles.—A. Mailhe and F. de Godon.—When di-isoamylamine is passed over reduced nickel heated

to 300—320°, isoamylnitrile is obtained, together with hydrogen, some isoamylene, tri-isoamylamine, and ammonia. Copper does not give the same result as nickel. Tri-isoamylamine in the same circumstances also yields isoamylnitrile. This reaction is unexpected, and further experiments will be made to see whether it is generally applicable to other secondary and tertiary amines.

Condensation, under the Action of Potash, of Cyclohexanol with Secondary Butyl Alcohol; Synthesis of 4-Cyclohexyl-3-butanol.—Marcel Guerbet.—The author has already shown that when cyclohexanol, $C_6H_{11}OH$, is heated to 215°, in presence of caustic potash with isopropyl alcohol, $CH_3—CHOH—CH_3$, it condenses to give cyclohexylisopropyl alcohol, $C_6H_{11}—CH_2—CHOH—CH_3$. He has now found that in the same experimental conditions cyclohexanol condenses with secondary butyl alcohol to give a hitherto unknown alcohol, which has been found to be 4-cyclohexyl-3-butanol. Thus the cyclic alcohol cyclo-hexanol behaves exactly like a secondary alcohol of the fatty series containing the same number of carbon atoms.

No. 18, October 29, 1917.

Distillation of Mixtures of Sulphuric and Nitric Acids.—Paul Pascal.—The author has determined the boiling-points of mixtures of water, sulphuric acid, and nitric acid, and gives the diagrams which show the results graphically. These diagrams give all the elements necessary for the theory of the concentration in retorts of weak nitric acid, and the denitration in towers of nitro-sulphuric acid mixtures.

Preparation of Acyl Hydroxylamines from the Oximes of α-Ketonic Acids.—J. Bougault.—By the action of iodine and sodium bicarbonate upon the oxime of an α-ketonic acid an acyl hydroxylamine is formed and carbon dioxide is eliminated. Thus phenyl pyruvic oxime, $C_6H_5.CH_2.CNOH.CO_2H$, gives phenylacetyl hydroxylamine, $C_6H_5.CH_2.CO.NHOH$, while at the same time some *nitrile, viz.*, $C_6H_5.CH_2.CN$, *is formed*. Other members of this new series of acyl hydroxylamines have been formed by similar reactions.

No. 19, November 5, 1917.

The amount of Nitrogen in Oxidised Coals.—P. Mahler.—Coal always contains a certain amount, varying from 0·7 to 2·5 per cent, of nitrogen. Samples of oxidised coal from Decazeville were analysed, and it was found that the percentage of nitrogen present was not much affected by the degree of oxidation.

MISCELLANEOUS.

Illuminating Engineering Society.—A Meeting will be held at the House of the Royal Society of Arts (John Street, Adelphi, London), at 5 p.m., on Tuesday, January 15, 1918, when a paper on "Ten Years of Illuminating Engineering—its Lessons and Future Prospects" will be read by Mr. L. Gaster.

Business Amalgamation.—Among the results of the present war has been the amalgamation of business firms. The latest instance of this is the incorporation of Messrs. Whittaker and Co., of White Hart Street, Paternoster Square, with Sir Isaac Pitman and Sons, Ltd. Messrs. Whittaker (of whom Mr. A. J. Rayment is the sole surviving partner, the other having given his life for the country) have long been known as publishers of scientific and technical books, and their catalogue enumerates many important books. Messrs. Pitman will enjoy the benefit of Mr. Rayment's experience and his knowledge of what is required by scientific and technical students, as he intends to direct from their offices the new department thus added to their undertakings.

"The Empire, its Commerce and Commercial Requirements."—A course of public lectures will be given at the London School of Economics and Political Science, Clare Market, Portugal Street, W.C. 2, on Friday evenings at 5 p.m. The following is the programme:—January 18—"Artificial Manures," by Sir Alfred Hall, K.C.B., M.A., F.R.S., formerly Director of the Rothamsted Experimental Station. January 25—"Fodder," by T. B. Wood, M.A., Drapers' Professor of Agriculture in the University of Cambridge. February 1—"Meat," by Mr. Charles Elgar. February 8—"Fibres," by Mr. Alfred Wigglesworth. February 15—"Timber," by Mr. W. R. Lenanton, J.P. February 22—"Wood Pulp and Paper-making Materials," by Mr. R. W. Sindall, Consulting Chemist, Specialist in Paper Technology. March 1—"Leather and Tanning Materials," by Dr. J. Gordon Parker, Principal of the Leathersellers' Company's Technical College.

Society of Public Analysts.—The Annual General Meeting of the Society will be held on Wednesday February 6, 1918, at the Chemical Society's Rooms, Burlington House, Piccadilly, W., at 5 p.m. The accounts for the year will be presented, the President will deliver his Annual Address, and the election of Officers and Council for the ensuing term will take place. The appointment of auditors will also take place. Mr. Norman Evers, the retiring Auditor, offers himself for re-election, and Mr. C. C. Roberts has been nominated in place of Mr. H. F. Stephenson. The Ordinary Monthly Meeting of the Society will be held immediately following the Annual General Meeting, when the following Papers will be read:—"A Modified Acetic Acid Reagent for Valenta Tests," by A. E. Parkes, F.I.C. "Oiticica Oil—a New Drying Oil," by E. Richards Bolton, F.I.C., and Cecil Revis, A.C.G.I., F.I.C. Seven candidates for admission to the Society will be balloted for.

NOTES AND QUERIES.

*** Our Notes and Queries column was opened for the purpose of giving and obtaining information likely to be of use to our readers generally. We cannot undertake to let this column be the means of transmitting merely private information, or such trade notices as should legitimately come in the advertisement columns.

Underground Temperatures.—Can any reader give me information with regard to the constancy of temperature at depths below 1000 feet? Any data extending over a period of up to ten years at intervals of about six months would be most useful.—E. R. O.

MEETINGS FOR THE WEEK.

Monday, 14th.—Faraday Society, 5.30. General Discussion on "The Setting of Cements and Plasters."

Tuesday, 15th.—Royal Institution, 3. "Palestine and Mesopotamia—Discovery, Past, and Future," by Prof. W. M. Flinders Petrie.

— Institution of Petroleum Technologists, 8. "The Petroleum Industry of Rumania," by Capt. T. S. Masterson.

Wednesday, 16th.—Microscopical, 8. Presidential Address, "The Royal Microscopical Society during the Great War—and After," by E. Heron-Allen.

— Society of Glass Technology, 3.15. (In the Music Rooms, Theatre Road, Stourbridge). "The Durability of Heavy Lead-Potash Glass," by J. D. Cauwood, W. E. S. Turner, and D. Webb. "Annealing of Glass," by S. English and W. E. S. Turner. "A New Blowpipe with Pre-heated Gas," by W. A. Whatmough. "A New Variable-jet Blowpipe," by S. English.

Thursday, 17th.—Royal Institution, 3. "Generalship—a Battle of Napoleon's (Austerlitz)," by Prof. Spenser Wilkinson.

Friday, 18th.—Royal Institution, 5.30. "Studies on Liquid Films," by Prof. Sir James Dewar.

Saturday, 19th.—Royal Institution, 3. "The Chemical Action of Light," by Prof. W. J. Pope.

THE CHEMICAL NEWS

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THE ORES OF COPPER, LEAD, GOLD, AND SILVER.

By CHARLES H FULTON.

Definition of "Ore."

It is difficult to define "ore" so as to include all the conceptions of the term that are and have been prevalent. The term may be given a technical and a scientific definition. The technical definition may be stated as follows:—

> An ore is a metalliferous mineral, or an aggregate of metalliferous minerals, more or less mixed with gangue, containing metal of commercial importance in such quantity that it may be extracted at a profit by the application of economic and skilful methods of mining and treatment.

This definition restricts the term "ore" to natural mineral products yielding a metal, and makes only such material "ore" from which the metal may be extracted at a profit.

The scientific definition may be stated as follows:—

> An ore is a metalliferous mineral that contains a metal that has found a recognised application in the arts and industries and occurs in such abundance in nature as to be of commercial importance.

This definition has reference more to the particular mineral, either native metal or compound, as distinct from the mineral aggregate or mixed mineral mass in which it may occur, and does not bring in the factor of quantity or profit. Thus, galena, the sulphide of lead, and argentite, the sulphide of silver, are ores of lead and silver in the scientific sense, irrespective of the quantity that may be present. In a mineral aggregate consisting of quartz, calcite (carbonate of lime), siderite (carbonate of iron), and a little galena, the last is the "ore" in the scientific sense, and the whole mass or aggregate is the "ore" in the technical sense, if the galena is present in sufficient amount to permit the extraction of lead at a profit. The "gangue" is the matrix of associated minerals in which the valuable mineral occurs, and must of necessity be mined from the ore body to recover the valuable mineral. The nature and the kind of gangue minerals are often important in determining details of ore-dressing operations and metallurgical treatment.

Although the gangue is always mineral in character, it may be divided into two classes—(1) the minerals that make up the vein filling between two more or less distinct rock walls that inclose the vein or ore body, and (2) the rock mass itself throughout which the valuable mineral may be disseminated.

Native metals or alloys, such as gold-silver, platinum and associated metals, and copper, were formerly not considered ore, but this exception is now obsolete. Thus the metallic copper disseminated throughout the amygdaloid rock in the Lake Superior district was formerly designated as "copper rock," but is now properly termed "copper ore." Metallic gold in quartz may be termed "gold quartz," but is also a gold ore. Native metals, particularly gold and platinum, are found also in gravel beds, concentrated therein at some time, ancient or recent, by the action of water currents, the metal having been removed from its original position in some ledge by denudation. These deposits are known as placer deposits, and, as regards gold, the valuable part is designated "gold gravel." This gold gravel is not considered an ore. In order to have the gold or other native metal considered as ore, it must be in place, that is, in its original position in the rock or mineral matrix.

Determination of Quantity or Ore in a Given Deposit.

In all mining operations a most important consideration is the quantity of ore as determined by the size and extent of the ore body or "ore deposit." The value of an ore deposit is determined by the following factors: (1) The size of the ore body—that is, the amount of ore; (2) the metal content of the ore; (3) the net return per ton of ore practicably obtainable—that is, the difference between the gross value and the total cost per ton of mining and treatment.

It is the common experience in American mining that the first factor, the size of the ore body or the amount of ore available, frequently fails to receive proper consideration. At the beginning of a mining operation it is difficult to form a correct idea of the amount of ore that a certain area of ground will yield, and under efficient administration of mining properties considerable prospecting is done by means of shafts, tunnels, drifts, and drill holes, with the object of outlining the extent of the ore body and determining the value of the ore.

On new mining ground, this kind of work is absolutely essential before the erection of a treatment plant or the investment of considerable capital in a permanent mining plant can be considered. On property that is regularly producing ore, exploratory work is necessary in order to establish the presence of ore in sufficient quantity to last for a certain time, at the daily capacity, ahead of immediate needs. This ore comprises the "ore reserves." The ore reserves in well-administered mines should be sufficient to insure at least a year's supply or more of ore, the extent of the reserves depending upon several factors, chiefly the nature of the occurrence of the ore.

When exploratory work fails to disclose the presence of sufficient ore, an investment of capital is clearly not warranted. As regards a working mine, when the exploratory work fails to reveal new reserves, arrangements are made to close the affairs of the concern as economically as possible.

The question of the "amount of ore" seems extremely simple. In reality it is one that can be answered in most instances only by the most expert work of experienced engineers. The ability to estimate the quantity of ore is frequently assumed by incompetent individuals, actuated by the hope of "what might be" rather than by facts. Such assumptions often lead to large expenditures of capital for a mining and treatment plant, which later on proves to be unwarranted. The vast number of decaying mining and milling plants in many parts of the United States is evidence, in large part, of mistaken judgment as to the quantity of ore. Other causes also operate, but their effect is not comparable to the one stated.

There is a strong tendency in recent years to exercise greater conservatism and less hopefulness in reference to the quantity of ore in mining ground. The performance of adequate exploratory work directed towards establishing extensive ore reserves, before the construction of milling and treatment plants, is the policy of modern mining corporations. Many of the larger mines of the country have ore reserves sufficient to last eight to ten years or more. There is thus an inclination to definitely outline and expose the ore in a given area before any considerable sum is expended for equipment rather than to trust to good fortune that the ore will be found as work proceeds from year to year. The quantity of ore exposed in some of the larger metal mines, especially in copper mines, is great. This policy aids in giving stability and permanence to the mining industry.

* *Technical Paper* 143, Department of the Interior, U.S.A. Bureau of Mines.

Size and Situation of Deposit and Value of Ore.

There is a great difference in the size of various ore bodies and in the value of ores. Thus, the Goldfield Consolidated mine in Nevada in the year 1910-11 yielded 266,867 tons of gold ore of the gross value of 40.72 dols. per ton, and in 1910 the Alaska United Gold Mining Co. obtained from the Ready Bullion mine on Douglas Island, Alaska, 232,330 tons, having a gross value of 2.43 dols. per ton. These two mines about represent the extremes of value in large-scale gold-quartz mining in the United States. Similar examples could be given for copper mining.

There is clearly a relationship between the quantity of ore and the value per ton. When the quantity of ore is sufficient to permit its being worked on a relatively large scale the value per ton that will yield a profit can be less than if the ore occurs only in relatively small quantities. Even though the value of the ore in a mineral deposit may be high, the deposit may be so small that its development is not warranted.

The situation of the ore body has an important influence. If the ore is situated on transportation lines, convenient to fuel supply, at a point where labour is plentiful and not high priced, ore of lesser value may be worked at a profit than if the situation is remote from transportation facilities and from the labour market. Thus, advantageous situation is a decided factor in the value of a mineral deposit. Whether a certain deposit can be worked depends, therefore, on the following factors: (1) Metal content of ore, (2) quantity of ore, (3) situation of the deposit, and (4) nature (complexity) of the ore.

A large ore deposit with an average copper content of 10 per cent situated at Butte, Mont., would be considered an extremely valuable property. The same ore body situated in an inaccessible part of the Desert of Sahara would be practically valueless at the present time.

Although a given mineral deposit may not be available now, it may become so later on by the influence of two factors, as follows: (1) A comparatively inaccessible location may become accessible by the extension of transportation facilities and the general advance of civilisation, and (2) improvements in methods of mining and ore treatment may make it possible to work lower grade material than has heretofore been possible. Predictions of the exhaustion of metalliferous deposits within a comparatively short time are often erroneously made because the above factors and the probability of new discoveries are not given sufficient weight.

Within the past few years great copper deposits—the so-called "porphyry coppers"—have become available as ore in Arizona, New Mexico, Utah, and Nevada. Ten years or so ago these deposits were practically not considered as being in any way available.

In valuing mines, and in mining reports, the term "average ore value" or "average value of the ore" is frequently used. Although in some ore deposits the valuable metal is rather uniformly distributed, so that each ton mined contains about the same amount of metal, other deposits show a rather wide variation in metal content throughout their extent and the value of the ore as mined varies. In working deposits of this kind a certain minimum metal content that the ore must contain is determined, and material with a lower metal content is not mined but is left in place, or if the conditions make its mining necessary, it is rejected before treatment. Determination of the lowest grade of ore that can be mined at a profit frequently involves close calculation, as the leaving in place of mineral material may have the effect of increasing costs more than if it is taken out and treated with the rest of the ore. The "average ore value" may thus be defined as the value per ton of the workable part of the ore body, taken as a whole.

No known economic method of metallurgical treatment can recover the whole of the metal content of an ore. There is always a loss, which varies with the metal to be recovered, with the nature of the ore, and with the method of recovery used. Broadly speaking, the recovery is greatest with gold, less with silver, and lowest for copper and lead. In milling processes recoveries of 90 to 96 per cent of the gold in the ore are not infrequent. In smelting processes these figures may be increased. In milling processes the recovery of the silver ranges from 60 to 92 per cent, and more in exceptional instances, whereas in smelting processes it is usually 90 per cent and over, although under certain conditions it may be less. The recovery of copper from ores ranges from 60 to more than 90 per cent, depending on the grade of the ore and whether it is concentrated before being smelted or is smelted direct, as concentration entails a considerable loss. The case of lead ores is similar to that of the copper ores, although the loss of lead in smelting is greater than in the smelting of copper.

These facts must be considered in valuing an ore, as the profit per ton is the difference between the gross value of the ore and the sum of the total treatment cost and the loss per ton. One other factor entering into the value of copper, lead, or silver ores, or ores containing them, is the market price of the metal, which frequently undergoes wide fluctuations. Although gold has a standard value, the price of the other metals varies so that the value of ore of certain metal content may change rather rapidly. An appreciable drop in the price of silver may, for instance, place a producing silver mine in the unprofitable class.

Classification of Copper, Lead, Silver, and Gold Ores.

The accompanying classification of ores is made on a metallurgical basis, the mineral composition of the ore, including the gangue, determining the method of metallurgical treatment. Whether an ore is designated as copper, lead, gold, or silver ore is determined by the metal that predominates in value, but not necessarily in quantity. Although certain ores are plainly copper, lead, gold, or silver ores, others contain two or more of the metals and their proper designation becomes more difficult, because the metallurgical treatment becomes more complex. Thus, although a copper ore containing gold and silver properly falls into the field of the metallurgy of copper, an ore that contains copper, lead, and gold belongs to the field of lead metallurgy if the lead is to be recovered. The basis adopted for the classification is therefore as follows: The metal first named in the ore type determines the primary method of metallurgical treatment, irrespective of what further treatment may follow in order to separate the metals in the ore. For example, a complex gold ore containing also silver and some lead minerals is treated by gold milling in which concentration is part of the process. The gold milling may include the recovery of some gold by amalgamation with mercury, followed by cyanidation for the recovery of more gold and some silver, followed by the concentration process that recovers the lead and other sulphides, with some gold and silver from the gangue, or worthless part of the ore. The valuable concentrates are then shipped to the lead smelter, which recovers the lead and the remaining gold and silver.

If, however, lead is the predominating metal in the ore even though gold may be present in considerable amount, the ore will be treated directly by the lead smelter.

Gold and silver are readily recovered in both copper and lead smelting, alloying easily with the copper or lead furnace products, from which they may be separated in the subsequent refining operations. Copper and lead are hence collecting agents for gold and silver, which may be recovered from any ore by the processes of lead or copper smelting. Broadly speaking, an ore will be treated by the most economic method available and, hence, gold or silver ores may make part of the furnace charge of lead or copper smelting operations if this treatment happens to be the most economical. Gold and silver ores, however, usually contain large amounts of silica or siliceous rocks as gangue, which may require the addition of much barren flux to the furnace charge, making the smelting costs high, as compared to milling costs. Therefore, the siliceous

gold and silver ores, comprising the great mass of these ores, are treated by milling processes distinctive of the metallurgy of gold and silver. In some instances these siliceous ores are necessary to properly balance the mixture of ores composing the furnace charge; then the cost of smelting and the rate on the ores may be such as to make smelting more desirable than milling. As stated, ores are mineral aggregates, and in many ores the valuable mineral is disseminated throughout a mass of valueless minerals. To smelt ores of this kind directly would be costly, and hence a cheap method of separating the waste from the valuable mineral is necessary. This is done by concentration, in which the valuable mineral is concentrated into relatively small bulk and the gangue is eliminated. Concentration is commonly carried out by crushing the ore, screening it into a number of different sizes, and washing these in water currents to remove the lighter gangue minerals, only the heavier valuable minerals being recovered. The separation is based on the specific gravity and the size of particles. Other modes of concentration are also practised, and recently "flotation" methods, in which the valuable heavy sulphide minerals are floated with an air froth, while the gangue sinks, are receiving wide application. Concentration may also be practised to separate one valuable mineral from another. Lead and copper ores are frequently concentrated before being smelted, and gold, and particularly silver, ores may be treated by a milling process that has a concentration step.

(To be continued).

THE VISCOSITY OF BLAST FURNACE SLAG AND ITS RELATION TO IRON METALLURGY, INCLUDING A DESCRIPTION OF A NEW METHOD OF MEASURING SLAG VISCOSITY AT HIGH TEMPERATURES *

By ALEXANDER L. FEILD, B.A., M.S. (North Carolina), Assistant Metallurgist, United States Bureau of Mines, Pittsburgh, Pa.

(Continued from p. 16)

The Desulphurisation Process and its Relation to Slag Viscosity.

The greater portion of the sulphur enters the furnace in the coke, in which it is present as ferrous sulphide to the extent of from 0·5 to 2·0 per cent sulphur. The total quantity of sulphur is for practical purposes entirely distributed between the molten iron and slag. It may be assumed quite safely that the sulphur which is dissolved by the pig iron exists as ferrous sulphide, FeS. On the other hand, it is necessary to assume in the case of the sulphur dissolved in the slag that it exists for the most part in normal slags as calcium sulphide, CaS. In high manganese slags, however, it is probable that a portion of the sulphur exists as manganese sulphide.

According to the well known distribution law of Nernst (33), when a substance is distributed between two immiscible solvents, such as molten iron and slag, the ratio of the concentrations of the given substance in the two solvents, when the condition of equilibrium is reached, is constant for any given temperature, *provided* the dissolved substance has the same molecular weight in the two solvents. Moreover, in the case of several dissolved substances each substance distributes itself as though the others were not present.

Let us consider an ideal case where manganese is entirely absent from the slag and iron. Since calcium sulphide is insoluble in molten iron, the distribution effect must be that of ferrous sulphide between molten iron and slag. The ferrous sulphide present in the slag undergoes the following reaction:—

$$FeS + CaO \rightleftharpoons CaS + FeO \quad . \quad . \quad . \quad . \quad (1)$$

* A Paper communicated to the *Transactions of the Faraday Society*. Published by permission of the Director, U.S. Bureau of M

Since the concentration of lime, CaO, is very large in comparison with the concentrations of the other reacting substances, it may be considered to be a constant; wherefore, it would follow, from the general law of chemical equilibrium (34), that the concentration of the ferrous sulphide in the slag would be proportional to the product of the concentrations of the calcium sulphide, CaS, and the ferrous oxide, FeO.

Assuming ferrous sulphide to be distributed according to Nernst's distribution law, the concentration of the ferrous sulphide, and therefore of the sulphur, in the pig iron would be proportional to the product of the calcium sulphide and ferrous oxide concentrations in the slag layer, provided no other side reactions occurred.

However, there is a side reaction which must inevitably occur, since ferrous oxide is not stable at high temperatures in the presence of carbon. This reaction is as follows:—

$$FeO + C \rightleftharpoons CO + Fe \quad . \quad . \quad . \quad . \quad (2)$$

On combining equations (1) and (2), the net effect is seen to be—

$$FeS + CaO + C = CO + Fe + CaS \quad . \quad . \quad (3)$$

Equation (3) is the usual one given by most authorities to illustrate the course of the desulphurisation process.

In the course of the chemical reaction represented by equation (3) it is necessary that FeS diffuse from the iron into the slag and also that the CaS, which is a product of the reaction, diffuse with sufficient rapidity to prevent the reversible reaction from coming to a standstill prematurely. For this reason the desulphurisation reaction is conditioned largely so far as its speed is concerned by the viscosity of the slag, and resolves itself into a reaction confined to a great extent to the boundary plane between molten iron and slag. This boundary plane exists around the molten iron globules previous to their fall to the bottom of the hearth and between the contiguous layers of iron and slag in the hearth. To what extent desulphurisation is completed previous to and during the fall of the iron globules through the slag layer is not known.

If it is true that during the smelting process equilibrium is reached under normal conditions in the case of the partition of sulphur between iron and slag, then the desulphurising power of any given slag is independent of the viscosity of the slag, as such. In such a case the distribution of the sulphur would be a function only of the composition of the iron and slag and of the temperature of the hearth. However, if equilibrium is not reached under normal conditions, there cannot be in the strict sense of the word a distribution of sulphur, since the laws of distribution refer only to equilibrium conditions. In this case the amount of sulphur absorbed by the slag depends on the speed of the reaction of desulphurisation, which, as has been noted above, is conditioned by the viscosity of the slag as well as by the temperature and composition of molten iron and slag.

With the help of the temperature-viscosity data of a number of different slags, obtained by means of the method which is described in this report, the Bureau of Mines is undertaking research investigations to determine the following facts: (1) by determining the speed of sulphide absorption by different slags at such temperatures as to possess identical viscosities, to deduce the effect due simply to differences of temperature and composition; (2) by determining the speed of sulphide absorption by the same slag at different temperatures, to deduce the effect due to changes in viscosity and temperature; (3) and by determining the speed of sulphide absorption by different slags at the same temperature, to deduce the effect due to changes in slag composition and in viscosity. Also, in each case, the final conditions of equilibrium are to be determined.

This work when completed should give a clear insight into the mechanism of the desulphurisation process, and should be a test of the validity of the theory of Turner (35) and of Schafer (36), which states that the silicate of the slag acts as a comparatively inert solvent for the

spinels (aluminates), which alone are capable of reacting with the sulphide sulphur in the pig iron. According to this theory a slag low in alumina should possess a relatively weak desulphurising power; and there should exist a lower limit of alumina content below which a slag cannot be made to act satisfactorily in the blast-furnace.

The Relation between the Composition of Blast-furnace Slags and their Softening Temperatures determined by the Cone Test.

In the absence of any method of viscosity measurement at the extreme temperatures of the blast-furnace hearth, it has been customary for investigators to obtain an idea of the softening temperature or deformation temperature of slags by means of the familiar cone tests, in which test pieces similar to Segar cones are made from the slag and the temperature noted at which these test pieces bend over, melt to a ball, or otherwise show signs of incipient fusion.

In the ceramic industries and also in determinations of the fusibility of coal ash, cone tests furnish valuable information, since in these cases the important point in view is to determine the minimum temperature at which deformation or softening occurs. If, for instance, a firebrick softens appreciably at 1600° C., it is not a matter of technical interest to know how this brick would behave at 1800° C., nor would a cone test give any information in regard to this question. Complete data in regard to such tests may be obtained by referring to the work of Seger, Hoffman, Simonis, Rieke, Kanolt, Bleninger, Boudouard, and Fieldner and Feild (*Notes* 37, 38, 39, 40, 41, 42, 43, 44).

Mellor (45) has defined the softening temperature concisely as follows: "The softening temperature measures the temperature at which the inward surface pressure of the substance becomes greater than those intermolecular forces which hinder the molecules taking up a position of stable equilibrium-minimum surface area."

It is undoubtedly true that silicate mixtures in general at temperatures at or near their softening-point possess a surface tension of considerable magnitude, as may be shown by the rounding off at the end of a glass rod when held in the flame of a Bunsen burner. When the softening-point test is made on relatively *small* test pieces, where the surface is large in comparison with the diameter, the deformation which the cone or similar object undergoes is necessarily affected to some extent by the existence of the surface effect. What is observed actually is the resultant effect of decrease of viscosity and action of surface forces upon the softened body. The magnitude of the surface effect cannot be determined by a series of experiments with cones of the same shape but of different dimensions, since on melting or softening a relatively large cone is subjected to a greater vertical pressure, analogous to a load pressure, *caused by its own weight. There exists then a need of a* more accurate knowledge of surface tension in the interpretation of cone tests in general, which would include an accurate method of measurement at high temperatures.

There are given in Table I. the softening temperatures and analyses of eighteen commercial slags. These determinations were made in a platinum wire resistance furnace in an atmosphere of air, temperatures being measured by a platinum platinum-rodium thermocouple calibrated by the Bureau of Standards. The sulphur content of the slag is accordingly entirely converted to the sulphate by the oxygen of the atmosphere, and possibly a portion was volatilised. The measurements cannot therefore be considered as representing entirely the conditions within the blast-furnace, with its atmosphere of carbon monoxide and nitrogen. The slags are arranged in the table in the order of increasing refractoriness.

While it it is impossible to draw any definite conclusions as to the variation of the softening temperature with the composition from these measurements, it is at once evident that, in so far as the effect of silica is concerned, low softening temperatures are in general associated with high silica content in the slag. In regard to the effect of lime or of alumina the data in the table yield nothing conclusive.

As is well known, the softening of a silicate mixture, such as blast-furnace slag, depends upon the amount of eutectic which is formed during incipient fusion and upon the viscosity of this eutectic. It is obvious that, given a sufficient amount of this eutectic to overcome the rigidity imparted to the test piece by the unfused portion, deformation will occur even though the eutectic possesses an extremely high viscosity. This softening may require time on account of the high viscosity of the eutectic mixture, but in cone tests sufficient time is usually furnished for this slow deformation.

TABLE I.—*Softening Temperatures of Slags by the Cone Tests.*

Slag. Lab No.	Percentage of SiO_2	Al_2O_3	CaO.	MgO.	CaS.	MnO.	Softening Temperature, °C.
22967	48	8	32	5	2·0	0·1	1244—1254
22965	38	10	40	4	3·1	1·2	1262—1264
22964	38	9	43	2	2·4	0·2	1263—1266
22968	44	9	40	2	2·7	0·2	1279—1279
22960	37	11	25	20	3·5	2·2	1297—1300
22958	34	27	27	6	4·9	0·3	1342—1342
22953	36	12	41	6	3·1	0·7	1331—1346
22956	35	11	42	7	3·6	0·5	1352—1357
22963	34	14	41	6	3·4	0·6	1343—1360
22969	34	12	43	6	3·2	0·5	1358—1364
22961	34	15	38	10	2·9	0·3	1365—1368
22955	32	16	44	1	4·4	0·1	1356—1390
22952	32	12	45	6	3·4	0·5	1383—1391
22957	31	15	36	10	5·5	0·2	1388—1398
22954	18	35	31	10	4·1	0·3	1410—1410
22966	32	11	44	4	5·9	0·5	1425—1441
22962	32	15	48	2	3·5	0·2	1403—1443

Reference to the work of Rankin and Wright (46) at the Geophysical Laboratory on the system lime-alumina-silica shows that the minimum ternary eutectic of this system is composed of CaO 23·25 per cent, Al_2O_3 14·75 per cent, and SiO_2 62 per cent, which melts at a temperature of 1170° C. Further examination shows that in all cases low-melting binery or ternary eutectics in the system lime-alumina-silica correspond to a higher silica content than is usually found in blast-furnace slags. It would follow, therefore, that in all blast-furnace slags which possess more than the usual amount of silica there is formed on incipient fusion a large amount of a low-melting eutectic, which, when it attains a sufficiently low viscosity, causes the test piece to soften visibly and deform.

It therefore follows that high silica slags, which are known to be more viscous at furnace temperatures than more basic slags, possess quite paradoxically a very low softening temperature. One might attempt to explain the high viscosity of silicious slags in practice by claiming *that such slags produce a low hearth-temperature, and that* the high viscosity is due to the low temperature of the slag. Whether this be true or not, the measurements which have been made in these investigations show conclusively that at all practicable hearth temperatures a silicious slag is much more viscous than a normal slag at the same temperature.

If, therefore, one should assume that the slags given in Table I. required the same amount of superheating above the softening temperarures there given, 200° C., for instance, no importance could be attached to subsequent deductions; because actual measurements of viscosity and temperatures show that during a range of 200° of superheating certain slags attain a fluidity three times as great as others.

Emphasis should be placed upon the distinction between the physical melting-point and the softening temperature of silicate mixtures, which latter are often loosely referred to as the "melting-point." The former refers to a temperature which is perfectly definite in the case of the majority of silicate mixtures, viz., the temperature at which the *last* crystalline phase disappears upon slowly

raising the temperature of the melt. Only in the case of silica (47) itself end certain alkaline felspars (48) does the physical melting-point appear to be a rather uncertain point. The softening temperature may differ enormously from the physical melting temperature, nor can deductions be made simply on the basis of melting-point determinations as to the relative positions of the softening and melting points, with respect to each other. For complete information in regard to the melting-points and stability relations of the silicates, the reader is referred to the monumental work (49) of Day, Shepherd, Rankin, Wright, Merwin, and Sosman at the Geophysical Laboratory.

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(To be continued).

THE CONSTITUTION AND FUNDAMENTAL PROPERTIES OF SOLIDS AND LIQUIDS.*

PART II.—LIQUIDS.

By IRVING LANGMUIR

(Concluded from p. 18).

Adsorption of Liquids by Solids.

THE heats of adsorption of various organic liquids when brought into contact with Fuller's earth, bone charcoal, or kaolin, have been carefully studied by Gurvich in an investigation of the nature of the forces involved in adsorption. (L. G. Gurvich, *Journ. Russ. Phys. Chem. Soc.*, 1915, xlvii., 805—27. As this excellent paper is in the Russian language, and has been especially translated for me, it may be worth while to give here Gurvich's results in some detail, especially since they have a very intimate bearing on my theories of the constitution of solids and liquids). Gurvich traces relationship between this heat of adsorption and such properties as chemical reactivity, solubility, latent heat of evaporation, dielectric constant, "internal pressure," and surface tension, explaining these relationships in terms of his previous mentioned theory of "physico-chemical forces."

TABLE VI.—*Heat of Adsorption.*

Substance.	Fuller's earth	Bone charcoal.	Kaolin.	Volume adsorbed from saturated vapour by 1 grm. of Fuller's earth (cc.).	Dispersive power. Per cent.
Amylene	57·1	—	78·8	—	1·54
Water	30·2	18 5	—	0·683	2·82
Acetone	27 3	19 3	—	0 684	1·72
Methyl alcohol ..	21 8	17·6	27·6	0·679	1·60
Ethyl acetate	18 5	16·5	—	0·636	1·05
Ethyl alcohol	17·2	16·5	24·5	—	—
Aniline	13·4	—	—	—	—
Amyl alcohol	10·9	10·6	20·4	—	—
Ethyl ether	10·5	—	—	—	0·90
Chloroform	8 4	14·0	15·7	0·611	0·86
Benzene	4·6	11·1	9·9	0·610	0·39
Carbon disulphide ..	4·6	8·4	9·9	0·621	—
Carbon tetrachloride	4·2	13·9	9·4	0·625	0·27
Hexane	3·9	8·9	7·2	—	0·22

The results of his determinations of the heats of adsorption are given in Table VI. These are the heats in small calories, liberated when 1 grm. of the absorbent is added to a relatively large quantity of the liquid in a calorimeter.

Gurvich remarks—

"A glance at this table shows that with all three absorbents, most heat is evolved when compounds with double bonds or those containing oxygen or nitrogen are used; and the least heat is generated by saturated hydrocarbons or such saturated compounds as carbon disulphide or tetrachloride. The substances which are most active chemically exhibit the most intense attraction for the absorbents.

"The most natural conclusion from this fact would be that in adsorption we have to do with rather unstable molecular compounds. It would seem that Werner's theory of secondary valence would thus find further confirmation; but further experiments have proved that this is not so."

Gurvich rejects the theory that these phenomena are the result of chemical forces for the following three reasons:—

* From the *Journal of the American Chemical Society* xxxix., No. 9.

1. He finds that amounts of different liquids adsorbed by a given amount of absorbent are not in agreement with stoichiometric relations. Instead, he finds that the *volumes* of the different substances adsorbed are very neally equal. In these determinations he placed 1 grm. of the absorbent in a Hempel exsiccator in presence of the *saturated vapour* of the liquid until the weight became constant, which required from fifteen to twenty-five days. The results thus obtained with Fuller's earth are given in the fourth column of Table VI. The volumes of liquid adsorbed from the vapour thus vary over only the relatively small range from 0·61 to 0·684 cc. per grm. The number of grm. molecules adsorbed per 100 grms. of Fuller's earth, however, vary from 0·65 for CCl_4 up to 3·79 for H_2O.

2 From experiments, and by reference to work of other investigators, he concludes that the range of the forces causing adsorption and the other phenomena considered, is always of the order of 3×10^{-6} cm. He experimented with silver foil and glass wool in *saturated vapours* of CCl_4, CS_2, and ethyl acetate. The absorbents were placed in six glass tubes within the exsiccator, and the increase in weight in twenty hours was determined. No further increase occurred in an additional twenty-two hours. The silver foil had a surface of 4150 sq. cm., while the glass wool (threads 0·018 mm. diameter) had a surface of 2250 sq. cm. By calculation from the increases in weight (20 to 50 mgs.) the "thickness" of the adsorbed film, in the six cases studied, were found to lie within the range between 2·6 and $3{\cdot}5 \times 10^{-6}$ cm.

Gurvich refers to results of similar magnitude obtained by Magners for the adsorption of SO_2 by glass, by Shapin for adsorption of CO_2, NH_4OH, &c., by glass, and by Parks for the adsorption of water vapour by glass. Quincke, Reinold and Roecker, Moro, Wensam, and others have obtained results of the same order of magnitude by entirely different methods.

Gurvich concludes—

"It seems to me, therefore, very probable that the physico-chemical force of attraction in all its manifestations is not limited to adjacent molecules, but reaches out upon a large number of more distant molecules, its influence gradually decreasing as the distance from the centre increases. (These views of Gurvich are cited here at such length because they appear to be the prevalent views among workers in this field. The insufficiency and unreliability of the data upon which these views are based are typical of nearly all the data upon which the general distinction between "physical" and "chemical" forces usually rests).

"The action of the force of chemical affinity involved in the formation of compounds according to more or less simple stoichiometric proportions, is limited to distances of atomic order, or at most to distances separating neighbouring molecules. The sphere of action of physico-chemical forces is many times greater.

3. "Finally, the third distinction between physico-chemical and purely chemical forces is the following:—

"The heat of reaction between any two elements, generally speaking, is the greater the more dissimilar the elements are. In the action of the residual chemical energy (physico-chemical forces) we see just the reverse; hydrocarbons and their immediate derivations generate much more heat (see Table VI.) with charcoal than with Fuller's earth or kaolin; alcohols and in general oxygen compounds act in just the reverse manner. In the study of solubility it was noted long ago that chemically similar substances dissolve one another more easily than dissimilar substances."

Gurvich gives these three reasons as convincing proof that adsorption phenomena are not the result of purely chemical forces. The heat of adsorption is, however, in some way clearly related to the chemical properties. This is due he thinks "to some residual energy in the chemical molecule intermediate in character between chemical and physical." This residual energy differs from the purely chemical in the three ways given above, but it also differs essentially from the potential energy of purely physical attraction by its specific action or "specificity."

In discussing the relation between these "physico-chemical" forces and "true chemical forces" Gurvich points out that chloroform, which is chemically more active than carbon tetrachloride, has the higher heat of adsorption (Table VI.). Among the alcohols there is a parallelism between the heat of adsorption and the velocity of esterification and also the heat liberated during the formation of complex compounds with magnesium propyl iodide.

Gurvich observes that when Fuller's earth is shaken up with hexane it settles out rapidly, leaving a nearly clear liquid, but with acetone the liquid remains turbid. The disintegration of the Fuller's earth by acetone can even be observed under the microscope. By determining the percentage of the Fuller's earth which remains n suspension in different liquids he determines the dispersive power as given in the last column of Table VI. The closeness of the parallelism between this phenomena and the heat of adsorprion is very striking.

The disintegration of the Fuller's earth by these liquids is looked upon as entirely analogous to the solubility of substance in a liquid, except that the particles in the latter care are smaller. In fact there is a rather close parallelism between the solvent powers of the liquids shown in Table VI. and the observed heats of adsorption. For example, benzol and unsaturated hydrocarbons are in general better solvents than the saturated. Chloroform is about ten times more soluble in water than is carbon tetrachloride. Benzol mixes in all proportions with methyl alcohol, while only 31 per cent of hexane can be dissolved in this alcohol.

In general the substances with high heats of adsorption have high dielectric constants.

Among closely related chemical compounds Gurvich finds that the substances with the higher heats of adsorption have in general the higher surface tensions, but this parallelism is not nearly as good as in the cases of the properties cited above.

The chemical properties of substances are characterised by their "specificity." Thus we usually cannot predict how a substance A will react toward a substance B merely from a knowledge of the behaviour of A and B (separately) towards a third substance C. Certain very general relationships may exist between different classes of substances, but we are not often able to express the chemical properties of a substance in terms of a single constant, as for example the gravitational properties of a body can be expressed by the mass, or the electrical properties by the electric charge.

Gurvich considers that this "specificity" is a sufficient criterion to establish a close relationship between "molecular" and "chemical energy," but for the reasons already given he feels compelled to class the molecular forces as physico-chemical. As illustrating the "specificity" of "molecular processes" he calls attention to the fact "that benzene and hexane liberate twice as much heat (Table VI.) with charcoal as with Fuller's earth, but acetone, ether, and alcohols yields on the contrary more with Fuller's earth than with charcoal."

From the viewpoint adopted in the present paper the forces involved in adsorption, surface tension, &c., are strictly chemical in nature, that is they do not differ in any essential respect from the forces causing the formation of typical chemical compounds. Let us see how this theory can be reconciled with Gurvich's experimental results.

Consider first the adsorption of a liquid by a plane solid surface. If the molecules of the liquid contain active groups the molecules will become oriented and will pack into the surface layer in much the same manner as in the case of oil films spread upon the surface of water. In general there will be a tendency for the number of molecules adsorbed to bear a simple integral relation to the number of atoms exposed in the surface of the solid.

When the surface is a cleavage plane from a crystal, so that the surface atoms are arranged in a regular lattice, the amounts of different liquids (or gases) needed to saturate the surface would probably frequently stand in stoichiometric relations with each other.

In fact the experiments with oil or adsorbed films on water have already shown that these stoichiometric relations are very common. Thus it was found that the number of molecules of different fatty acids adsorbed per unit area was practically the same for all the acids from propionic up to cerotic. Similarly the number of molecules of stearic acid per unit area was three times that found for tristearine, &c.

It is evident that the configurations of the adsorbed molecules in general are of great influence in determining the number of molecules that can be adsorbed per unit area. This phenomena is, however, nothing more than *steric hindrance*. In adsorption phenomena, particularly on solid bodies, this steric hindrance must be of very far-reaching significance, much more so for example than in the fields ordinarily covered by organic chemistry.

Suppose we consider the adsorption of two such substances as methyl alcohol and phenol. Since the phenyl group will necessarily occupy more space than the methyl group, the number of molecules of phenol per unit area of a saturated surface will be less than that of methyl alcohol.

We might still expect that the number of phenol molecules would bear a simple relation (such as ½ or ⅓) to the number of methyl alcohol, but when we take into account the thermal agitation and the kinetic interchange which must occur, it appears more probable that the relative numbers of molecules adsorbed would bear an incommensurate ratio. This would be especially true if instead of a cleavage surface we should give a surface of an amorphous body as absorbent.

Now in the case of porous bodies such as those employed in Gurvich's experiments, there are cavities of nearly all possible sizes and shapes. It is obvious, therefore, that the phenomenon of steric hindrance will become of dominating importance, and that even in the case of a series of homologous acids or alcohols we should no longer expect to find stoichiometric relations. For example, the number of ethyl alcohol molecules which could attach themselves to the walls of a small cavity would be less than the number of methyl alcohol molecules which could be similarly attached. This difference will become more and more marked as the size of the cavities becomes smaller.

This absence of stoichiometric relationship, therefore, is not to be regarded as evidence that the forces involved are not chemical in nature. It is merely the result of purely geometrical factors. In fact, apart from reactions involving primary valence forces, it seems that stoichiometric relations are the exception rather than the rule, and that where these relations do hold it is merely the result of particularly favourable geometric conditions.

The heat of adsorption is determined in general by the interaction of the active groups and the atoms of the solid body. Thus in Table VI. we see that those groups which cause oils, &c., to spread on water surfaces are just those which cause an increase in the heat of adsorption.

Those groups or radicals are the double bond, $-OH$, $=CO$, $-COO-$, $-NH_2$, $-O-$.

The parallelism between these heats of adsorption and the phenomena described in the early part of this paper could hardly be more striking. There can be no reasonable doubt but that the causes of the adsorption are in both cases fundamentally similar.

Let us now consider from the viewpoint of our theory the three reasons which led Gurvich to decide that these adsorption phenomena are not due to chemical forces.

1. We have already seen that the absence of stoichiometric relationship cannot be taken as a proof of the absence of chemical combination, but that it is simply a result of steric hindrance.

It remains to explain why Gurvich's experiments showed that the *volumes* adsorbed were the same for all the liquids. It must be noted that Gurvich allowed the adsorption to occur in saturated vapours, and that equilibrium was not reached for from fifteen to twenty-five days. Under such conditions every small cavity must fill up completely with liquid because of the decrease of vapour pressure caused by the concavity of the surfaces in the pores of the absorbent. This is a purely secondary phenomenon, being dependent only on the surface tension of the adsorbed liquid, and not o the forces acting between the absorbent and the liquid.

We must picture the processes occurring during the adsorption of, for example, ethyl alcohol by charcoal as follows:—The hydroxyl groups of the alcohol are attracted to the carbon atoms, so that as many carbon atoms as possible come into contact (or combine) with the hydroxyl groups. The ethyl groups fill up many of the small cavities, and in other ways prevent the hydroxyl groups from coming into contact with the carbon atoms. The larger pores or cavities are, however, covered over with a single layer of molecules. When the vapour is *saturated* it is evident that these cavities must also gradually become filled with liquid. But this is to be classed as a capillary phenomena and not as adsorption. It has, for example, nothing to do with the forces acting between the carbon atoms and the hydroxyl groups.

Under these conditions it is only natural that the volume *absorbed* should be about the same for different liquids, since it is simply a measure of the total volume of the larger pores. The amount truly adsorbed is much smaller, and in the case of the three alcohols given in Table VI. is probably quite accurately proportional to the observed heat of adsorption. The three values, 21·8, 17·2, and 10·9, for methyl, ethyl, and amyl alcohols, adsorbed by Fuller's earth, indicate how marked is the effect of steric hindrance.

2. Gurvich and many other workers in this field lay a great deal of stress on the supposed fact that the range of the molecular forces is about 3×10^{-6} cm., or at any rate is larger than molecular dimensions. According to our theory, however, the range is rather of the order of 10^{-8} cm.

Gurvich experimented with 4150 sq. cm. of silver foil in a small tube. This was probably crumpled up loosely and squeezed into the tube. In any case it would be practically impossible to get such a large surface into a tube without having an enormous number of surfaces of contact between adjacent pieces of foil. These capillary spaces in *presence of saturated vapour* or even vapour anywhere near saturation must become filled with liquid held by surface tension and not by adsorption. The same objection may be raised against the experiments with glass wool.

We have seen in Part I. that other data given in the literature are unreliable for similar reasons.

I have not studied in detail all the references cited by Gurvich as evidence of the large range of molecular forces, but the evidence of a contrary nature which has already accumulated is enough to make me feel confident that the large ranges are only apparent, and are due to secondary causes.

To obtain further information regarding the forces causing adsorption and the thickness of adsorbed films some experiments have been undertaken for me by Mr. Sweetser. We have used glass, mica, and platinum with very nearly plane surfaces, and have endeavoured to reduce the number of contacts between surfaces to a minimum. The pressures used were much below saturation and were usually less than 200 bars. It was found that at 100 bars' pressure the amount of oxygen, nitrogen, hydrogen, carbon monoxide, carbon dioxide, and argon adsorbed on glass or mica at room temperature were not measurable, although if 0·0002 of the surface had been covered by a layer one molecule deep it could have been readily

detected. On cooling these surfaces to liquid air temperature the surfaces became covered with a monomolecular layer to the extent of 1 to 10 per cent, and at 100 bars' pressure they seemed nearly saturated. The relative amounts of different gases adsorbed were in the same order as the boiling points, showing that the forces involved in this adsorption were secondary valence forces such as those involved in the liquefaction of these gases.

With platinum surfaces the phenomena were totally different. Even at pressures below one bar the surface adsorbed hydrogen, carbon monoxide, or oxygen immediately to form a layer covering the surface with a layer approximately one molecule (or atom) deep. These films could not be driven off by heating to 360°, but could be made to displace one another. The surfaces were wholly saturated at a few bars' pressure, and no increase in adsorption could be noted by raising the pressure to 200 bars. These films are evidently held to the platinum by primary valence forces.

With the platinum at liquid air temperature the gases are first adsorbed by secondary valence forces, because when the temperature is raised to room temperature the gas first comes off the surface, and then at a temperature somewhat below room temperature goes back again on to the surface.

In no case, however, was any adsorption noted which corresponded to a layer more than one molecule deep.

It is, of course, possible in certain exceptional cases that more than one layer of molecules may be adsorbed on a surface. The tendency of molecules to evaporate from a second layer will in general be somewhat different (either greater or less) than from the surface of the liquid *en masse*. Such effects may be transmitted from layer to layer because of the orientation of the first layer of molecules, but in most liquids these effects are probably not transmitted in appreciably degree to more than one or two layers. Effects of this kind would be particularly noticeable with nearly saturated vapours.

From the foregoing considerations we may conclude that the "molecular forces" studied by Gurvich are really chemical forces according to all the tests given by him, and that their range of action is not greater than that of other chemical forces.

3. Gurvich's third objection to classing molecular forces as chemical is that they seem most active between similar rather than dissimilar bodies. This objection, however, arises merely from a confusion of secondary and primary valence forces.

In the formation of compounds of the first order we generally find the most marked combining tendencies between strongly electronegative and electropositive elements, as for example between the alkali metals and the halogens. This tendency is most readily explained in terms of Lewis's theory.

On the other hand, all through chemistry we find evidence of reactions occurring between substances of similar type, especially where secondary valences are involved. This is shown by reactions between oxides, between halides, between metals, &c., and even by the reactions occurring between various organic compounds. Therefore, the fact that substances of similar character are usually mutually soluble, or that absorbing agents show a preference for chemically related substances is not to be looked upon as evidence that these phenomena differ in any essential respect from chemical phenomena, but merely as an indication that secondary rather than primary valence forces are involved.

As a final result of this discussion of Gurvich's paper we may conclude that the principles outlined in the beginning of the present paper are applicable to adsorption phenomena in general.

(In the remaining part of this paper surface tension, association, evaporation, freezing, melting, viscosity, solubility, and the internal structure of liquids will be briefly considered).

THE NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES, HELD IN NEW YORK.*

By THOMAS H. NORTON, Ph.D., Sc.D.

(Continued from p. 20).

John Campbell and Co., Newark, N.J.

The company exhibited its "Amidine" series of direct cotton colours, the "Kromeko" series of fast chrome dyes, the "Aceko" series of acid colours, and the "Liberty" series of dyes for the hat trade. The various intermediates employed in their manufacture were also shown.

Niagara Alkali Co., Niagara Falls.

This company is engaged extensively in the electrolysis of salt, and markets the various soda products, as well as chlorine and bleach. It is now using large amounts of chlorine in the manufacture of chlorobenzene, and exhibited this compound as well as dichlorobenzene. The latter was in the form of the commercial mixture of the isomers, as well as the pure ortho and para compounds. The whole exhibit illustrated admirably the degree of perfection attained in the development of the chlorine industry, as based upon electrolytic methods, and the use of the halogen in the production of coal-tar intermediates.

Hooker Electrochemical Co., Nigara Falls.

This company also had a fine display of the products of the soda and chlorine industry. It exhibited chlorobenzene, *o*-dichlorobenzene, *p*-dichlorobenzene, benzyl chloride, benzyl alcohol, benzaldehyde, and benzoic acid. The manufacture of the last four compounds has been taken up quite recently. This company was one of the first to show the advantage of transforming coal-tar crudes into their chlorine derivatives at the points where chlorine is produced electrolytically.

John Merck and Co., New York.

In addition to a handsome display of alkaloidal, pharmaceutical, and general chemicals manufactured by this company in their works at Rahway, N.J., there were exhibited a large number of their current coal-tar products. These included the pure hydrocarbons, benzene, toluene, xylene and naphthalene, aniline, *p*-nitraniline, acetanilide, benzidine sulphate, nitro-benzene, *m*-dinitro benzene, *m*-phenylene diamine, *p*-phenylene diamine, phenol, *o*-nitrophenol, *p*-nitrophenol, *p*-amidophenol, phenolphthalein, resorcin, hydroquinone, sulphocarbolates, β-naphthol benzoate, bismuth β-naphthol, salicylic acid, methyl salicylate, acetylsalicylic acid, acetphenetidine, salol, aurine, induline, and nigrosine. The exhibit was instructive, and revealed the wide range of activity of this long-established firm. Its coal-tar products are chiefly for medicinal and photographic use.

The Monsanto Chemical Works, St. Louis.

The exhibit of synthetic medicinals was finely arranged, and included the intermediates employed in making the different compounds. The coal-tar products shown were acetanilide, phenacetin, aspirin, phenol, U.S.P., phenolphthalein, saccharin, salicylic acid, salicylate of soda, and salol.

This company is doing excellent work in establishing upon a solid basis the American manufacture of synthetic drugs from coal-tar crudes. It exhibited also vanillin, which it is now producing regularly.

Chromos Chemical Co., New York.

The exhibit was confined to fine samples of benzoic acid and sodium benzoate.

* From the *Chemical Engineer*, October, 1917.

H. A. Metz Laboratories, Inc., Brooklyn.

The exhibit of this recently orgainsed company contained an admirable display of its synthetic medicinals, salvarsan, novacain, and anæsthesin. All of the intermediate steps in the production of salvarsans from aniline and arsenic acid were shown in carefully prepared samples. The establishment of the manufacture of this important synthetic drug on American soil is one of the leading features of the year's progress.

General Bakelite Co., New York.

Bakelite was shown in a great variety of forms, intended for the most diverse usages, but chiefly in connection with electrical insulation. It is the trade name of a unique synthetic substance, oxy-benzyl-methylen glycol-anhydride, discovered by Dr. L. H. Baekeland, after a series of brilliant research experiments, and is a condensation product of phenol and formaldehyde. In its pure form it is a hard amber-like substance of pronounced chemical inertness. It combines high mechanical and dielectric strength with marked heat resistance, and can be moulded with great accuracy and fine finish. It is also non-hygroscopic, impervious to water, steam, oils, and most chemicals; has excellent weathering qualities, and will not warp, soften, swell, or deteriorate with age.

This unusual combination of properties has rendered bakelite available for a great number of purposes. An especial degree of interest is attached to it as one of the few coal-tar products discovered in this country and introduced into general technical use.

The Stamford Extract Manufacturing Co., Stamford, Conn.

The successor to the old Stamford Manufacturing Co. displayed fine samples of the different dye-woods, as well as of quebracho, and the different extracts obtained from them in its large works. There were numerous examples of the results secured with them in dyeing. The hematin crystals were especially noteworthy.

The Obex Co., Marietta, O.

This firm is one of the latest to enter upon the production of dye-wood extracts. It showed particularly fine cross-sections of Brazil wood, fustic, logwood, and Osage orange, and a complete collection of the various extracts. The firm is planning to enter also upon the production of synthetic dyes.

Imperial Colour Works, Glens Falls, N.Y.

Exhibits were made of lakes and toners made from *p*-nitraniline and from toluidine, in company with a variety of dry and pulp colours. There was also a good display of vegetable dyes manufactured in the plant of John H. Heald and Co., Lynchburg, Va. It included extracts of logwood, fustic, and hypernic, hematine crystals, fustic crystals, wool and leather yellows.

The Buffalo Foundry and Machine Co., Buffalo, N.Y.

The exhibit of this company was the most imposing and the most extensive in the Exposition, occupying the entire western end of the main floor. It revealed in a remarkable way the complexity of the mechanism now employed in the production of chemicals and dye-stuffs, and the contributions of mechanical engineering in this field. The company has been an important factor in furthering the rapid development of our domestic coal-tar chemical industry, by devising the requisite apparatus, and by rapidly supplying it in great quantities to newly organised firms.

The *pièce de resistance* at the Exposition was certainly its vast vacuum drum dryer, weighing 50 tons, with its two-stage dry pump, surface condenser and dust collector. One of the greatest successes in American foundry work is represented by the huge casing of the dryer, cast in a single piece.

A similar vacuum dryer, in full operation, and an autoclave, holding 200 gallons, and working under 1000 lbs. pressure, excited much interest, as did a jacketted receiver, an enormous nitrator, a capacious fusion kettle, and a denitrator. There were numerous types of evaporators, for rapid circulation, for high concentration, for crystallisation, with horizontal and vertical tubes, &c.

Among other forms of chemical apparatus shown by installation or plans, were:—Acid eggs, acid concentrating apparatus, β-naphthol plant, caustic flaking machines, caustic soda plant, causticising apparatus, reflux condensers, crystallisers for TNT, ammonium nitrate, &c., vacuum crystallisers, expansion tanks, impregnating apparatus, nitric acid retorts and condensers, pumps of many types; recovery systems for sulphuric and nitric acids, retorts (shell type), salt filters, stills for aniline, β-naphthol, phenol, &c., and sulphonators.

A large staff of engineers and chemists were in attendance, and the decorations and settings for the exhibit were in admirable taste. It testified in a striking manner to the exceptional claims which the chemical industry now makes upon the mechanical engineer.

J. P. Devine Co., Buffalo, N.Y.

A handsome exhibit of vacuum pumps, condensers, drying apparatus, and high pressure cast-steel autoclaves, such as are now used extensively in making coal-tar intermediates and finished products.

The Pfaundler Co., Rochester, N.Y.

There was a fine display of the different forms of chemical apparatus, lined with resistant enamel, now required in variety by the manufacturers of coal-tar products, when dealing with strong acids. The specialities of this firm are highly appreciated in other countries, and a branch factory was maintained in Germany prior to the war.

Elyria Enamelled Products Co., Elyria, Ohio.

The exhibit included a number of pieces of chemical apparatus lined with enamel. This firm specialises in the production of enamelled tubes.

Sowers Manufacturing Co., Buffalo.

An excellent display of steam-jacketted kettles, mixers, vacuum-pans, &c.

Shriver and Co., Harrison, N.J.

Various types of filter-presses.

United Filters Corporation, Brooklyn.

An instructive exhibit of new types of filters in constant operation.

Kelly Filter Press Co., Salt Lake City.

Presses were shown in regular operation.

Arthur D. Little, Inc., Boston.

This firm is doing fine work as consulting and construction chemical engineers, and exhibited interesting evidences of the character of the work accomplished by its staff of sixty, occupying a handsome building at Cambridge, Mass.

Civic, State, and Railroad Exhibits.

A striking feature were the extensive collective exhibits of states, cities, railroad companies, and public organisations. Noteworthy in this connection were the large and instructive displays made by Louisiana and by Texas, as well as by the Southern R.R. system, the Carolina, Clinchfield, and Ohio R.R., the Central of Georgia R.R., the Nashville, Chattanooga, and St. Louis R.R., and the Norfolk and Western R.R. of Virginia. The south is making a vigorous effort to direct attention to the vast undeveloped wealth in its territory, awaiting the advent of chemical industry. The great variety of samples and

geological charts testified eloquently to the possibilities for creating manufacturing centres of mineral products in this section. The handsome exhibits of Baltimore and of Knoxville, Tenn., attracted much attention.

An official of one of the exhibiting railroads gave the following explanation of why his company found it desirable to participate in a chemical exposition:—

"It might be wondered why a concern with but one product to sell, which, strictly speaking, is not competitive but is an essential—the absolute basis—of all industrial products, transportation should take the trouble, expend the money, and use up the time of part of its personnel to attend an exposition of this kind, but if you will look over the exhibit you will find that several railroads have done this. What is the reason?

"All railroads have at least two kinds of industries—those that 'just grow," and those that are planted. The first get there of their own accord, generally without the railroads' officials knowing or caring much about what was going on until their new neighbour began calling for cars; the second, the planted kind, often require nursing beyond the age when weaning is generally considered. These seem to me to be a middle ground, largely uninhabited, in matters of this kind which is much better for all concerned, and it is our firm belief, and I believe it is that of all of the increasing number of railroads who are taking advantage of this great opportunity to show their wares, that those roads which pursue a broadminded and liberal policy toward the intelligent aiding of new enterprises to become substantially established are they whose securities will be the real investment of the future."

(To be continued).

ELECTRICITY FOR THE NATION.

One of the most far-reaching suggestions towards national reconstruction is set forth in an interim report made to the Ministry of Reconstruction by the Coal Conservation Sub-Committee. The report is now issued to the public with the following preface by Dr. Addison:—

Ministry of Reconstruction.

This report, which was presented to the Reconstruction Committee, is issued for the information of the public, and in the hope that the very important matters with which it deals may receive adequate consideration at the hands of all those likely to be affected by its proposals.

It will be observed that important issues affecting municipalities and public bodies are raised in the report, and they will be explored in all respects by the Government before any action is proposed to Parliament upon the subject. In its legislative aspect the whole matter is being investigated by a Committee appointed by the Board of Trade, and presided over by Sir A. Williamson, M.P.

(Signed) C. Addison.

The Sub Committee proposes briefly, to supply all our industries with electrical power generated at big "super-power stations," not more than sixteen in number for the whole country, and to eliminate or combine all smaller stations.

The primary object of the scheme is to economise our coal supplies. The amount of coal used in the United Kingdom for the production of power is 80,000,000 tons, at a cost of, say, £40,000,000 at the pithead. The Committee confidently states that, by an up-to-date and national scheme of electrification, 55,000,000 tons of this (£27,000,000 a year) could be saved. This, with a saving of the by-products now wasted by the burning of coal in open grates and boiler furnaces would effect a national economy of £100,000,000 a year.

The most economical way of obtaining power from coal on a large scale is by generating electricity from it. The coal now used, says the Committee, would, if used economically, produce at least three times the present amount of power. An increased use of power is of the highest importance to the future prosperity of the country. It is the best way to increase the net output per head and, therefore, the prosperity of the worker. "The best cure for low wages is more motive power."

In the United States the amount of power used per worker is half as much again as in the United Kingdom. Leaving out of consideration workers in trades where the use of power is small or even impossible, it is probably nearly double what it is here.

It has been settled conclusively during the past fifteen years that the most economical means of applying power to industry is the electric motor. In the factories put down for the production of munitions during the war, 95 per cent of the machinery is driven by electricity, and it is only a question of time for all power to be applied in this way. The problem is not how to apply electric power but how best to generate it.

The development of electricity in this country has been hindered by the numerousness and the smallness of the electrical undertakings. At the present time the supply of electricity in Great Britain is split up among about six hundred companies and municipal undertakings. The average generating capacity of such of these undertakings as possess power stations is only 5000 horse-power, or about one-fourth of the capacity of one single generating machine of economical size, and about one-thirtieth of that of a power station of economical size. Technically and commercially the big generating station is admittedly the best.

The reform proposed by the Committee is to supersede all these small undertakings by laying down throughout Great Britain main trunk lines to be fed by some sixteen "super power stations."

The generating machines in these stations should be of large size, not less than 20,000 horse-power each. In more important industrial districts machines of as much as 50,000 horse-power might be used with even greater advantage. The generating stations should be on large sites with ample coal and water transport facilities. It is contemplated that at each generating station by-products might be extracted from the coal before it is used for the production of power, and that various electro-chemical processes which are essential for this country should be carried on near by. The sites for the stations must be outside, not inside towns. This would improve the health of the great industrial centres by the reduction of smoke, and would relieve the congestion of the railway lines in their neighbourhood by practically abolishing the carriage of coal.

Various forms of electricity supply authority, both public and private, are considered, but the Committee, on the whole, favours private enterprise. They are "impressed with the special need for initiative and resource in the management of the business of power supply, and they are of opinion that the freedom of range and keenness which are distinctive of private enterprise will be found to be in a high degree conducive to the fullest measure of success."

The sixteen great power authorities, whether private companies or public bodies, would be controlled by a National Board of Electricity Commissioners. Existing plants would be handed over on equitable terms to the new authorities. In addition to the main generating stations, subsidiary generating plants would be set up wherever there was surplus gas or waste heat, as at blast furnaces and coke ovens, and the electricity so generated would be fed into the main-trunk system. In the same way, waste coal, which is not at present worth the cost of carriage, and is, therefore, left at the pits, could be used on the spot.

There already exists in this country a practical example of centralised production of electricity for a large area. The north-east coast district, rather larger in area than

Lancashire, is served by a group of power companies from one inter-connected electrical system. The population of this area is less than that of Lancashire, and the area is, therefore, less advantageous for electrical supply. But, whereas in Lancashire, with its multiplicity of electrical undertakings, the price per unit for electric power varies from a penny to twopence or more, the average price paid in the north-east coast district is less than a half-penny a unit, and the use of electric power per head of population is three times as great. A great saving of coal and reduction of smoke has resulted. Apart from the electric-power companies' consumption, practically no coal is burnt on the Tyne for power purposes, except by the railways and some collieries. The Tyne shipyards may be said to have adopted electricity to the exclusion of all other forms of power. As a result of the adoption of electric traction on the suburban railways, the traffic facilities of the district are greater than those of any other district of similar size. New industries have been established in the district, solely on account of the cheap electric power available. Waste heat and gases have been extensively used for the production of electricity, so that electric power is produced as a by-product of two of the largest local industries—the making of pig-iron and coke. These local generating stations are commonly called "waste-heat stations." The first was erected in 1905, and there are now eleven at work.

The Committee foresees, as a result of a national system of electric-power supply, a great increase of the use of electricity for all purposes, with many advantageous results. Factory chimneys would gradually disappear. Railways would be electrified, even for the haulage of goods trains. Smoky would disappear from our towns and coal waggons need run no farther than to the electric-power stations. Electric light would be cheap enough for the poorest, and there would be a large increase in the use of electric heat and power for household purposes.

As showing the importance of the scheme the report says: "It is scarcely possible to exaggerate the national importance of a technically sound system of electricity supply, because it is essentially one with the problem of the industrial development of the country."

"The development of such a power system may be likened to the development of the railways of a country, and it is just as impossible to secure economical power generation and supply by each municipal area working independently (which is the position to-day) as it would be to have an efficient railway system if each municipal area owned its own lines and long-distance transport were provided for by running-power agreements. History shows that, in the early stages of railway development in this country, exactly the same process of amalgamation had to be gone through."

PROCEEDINGS OF SOCIETIES.

FARADAY SOCIETY.

Annual General Meeting, December 12, 1917.

Mr. W. R. Bousfield, K.C., F.R.S., Vice-President, in the Chair.

The resignation of the Treasurer, Dr. F. Mollwo Perkin, who had acted in that capacity since the formation of the Society in 1903, was received with much regret. Mr. Robert Mond, F.R.S.E., was elected as his successor.

The following Officers and Members of Council were also elected:—

President—Sir Robert Hadfield, Bart., F.R.S.

Vice-Presidents—W. R. Bousfield, K.C., F.R.S.; Prof. F. G. Donnan, F.R.S.; Dr. Eugene Haanel; Prof. A. K. Huntington; Dr. T. Martin Lowry, F.R.S.

Council—W. R. Cooper; Dr. C. H. Desch; Dr. J. A. Harker, F.R.S.; Emil Hatschek; Cosmo Johns; Prof. Alfred W. Porter, F.R.S.; E. H. Rayner; A. Gordon Salamon; Dr. George Senter; Cav. Magg. E. Stassano.

The Report of the Council stated that in spite of adverse conditions the past year has perhaps been one of the most fruitful in the history of the Society, whether measured by the interest of the meetings held, the value of the work published, or its activities in the wider field of scientific and technical progress.

Early in the year the Society presented a Memorandum to the Ministry of Munitions on the Production of Synthetic Nitrogen Compounds, and as an outcome of a Conference which took place between representatives of the Society and of the Munitions Inventions Department of the Ministry, a Nitrogen Products Committee of the Department was formed.

The Society has presented to the Department a series of sectional reports on many of the aspects of the problem under consideration, drawn up by Messrs. W. R. Bousfield, W. R. Cooper, E. Griffiths, F. M. Perkin, and F. S. Spiers, and it has also initiated some experimental work.

The Society is conducting a research on "The Setting and Disintegration of Salts and other Crystalline Substances" for which it has received a grant from the Department of Scientific and Industrial Research.

General Discussions held in the course of the year included one on "Methods of obtaining High Temperatures in the Laboratory," and another on "Refractory Materials," which proved to be a function of outstanding importance attracting widespread interest.

In conjunction with other societies, the Faraday Society was instrumental in calling together a Conference to discuss means for carrying into effect a scheme of co-ordination between the various bodies interested in refractories research and standardisation. Later in the year a second Conference was held which resulted in the appointment of a Provisional Organising Committee to draft a scheme for a proposed Association for Refractories Research for the consideration of the industries concerned.

RÖNTGEN SOCIETY.

At a meeting of the Röntgen Society, held on January 1, 1918, Mr. Carl Darnell read two papers communicated by Dr. Coolidge, of the General Electric Co.'s Research Laboratories, U.S.A.

The first dealt with a new form of Coolidge tube, in which the anticathode consists of a block of copper faced with a small button of tungsten. This is fixed to a thick stem of copper, which passes out through the glass neck of the tube, and terminates in a fin radiator. The anticathode is thus kept cool, and does not in consequence emit electrons as in the case of the earlier Coolidge tube, in which the whole of the anticathode speedily becomes red hot. The new tube therefore so completely rectifies current that when an alternating potential is applied only one phase of the current will pass.

In the second paper, by Dr. Coolidge and Mr. Moore, the Portable or Field X-Ray Outfit of the United States Army was described. A petrol electric unit supplies alternating current at 110 volts to a transformer arranged to give both high tension and heating currents for the new radiator type of Coolidge tube. For simplicity of control the tube is worked at a constant potential of 5 minutes equivalent spark-gap, and the current is adjusted to 5 milliamperes for continuous running of the tube or to 10 milliamperes for short periods. An electrically actuated control on the throttle of the engine maintains constant output. The small size of the bulb, 3½ inches in diameter, enables a close-fitting lead-glass shield to be employed; this is made in two parts, and completely surrounds the tube, a suitable aperture permitting egress of the rays.

NOTICES OF BOOKS

Education, Scientific and Humane. Edited by FREDERIC G. KENYON. London: John Murray. 1917. Pp. 32. Price 6d. net.

THIS pamphlet has been issued at the request of the Council for Humanistic Studies, and is the outcome of an endeavour to arrive at a general agreement regarding the *principles and main outlines of secondary education*, so that future discussion of details may show a less extreme and more tolerant spirit than in the past. The Conference, representative of the Classical, English, Geographical, Historical, and Modern Language Associations, drew up a *series of resolutions upon* which the Methematical Association and the Association of Public School Science Masters expressed their opinion, at the same time outlining their own aims. The statement of the latter Association regarding the value of scientific teaching in fostering a love of truth and in giving a valuable knowledge of the employment of the forces of nature and the sequence of cause and effect will be generally approved. So far the main points of agreement seem to be that early specialisation should be avoided, and that the doors of all subjects should be open to all pupils. In a later conference between the Sub-Committee on Education of the Board of Scientific Societies and the Council for Humanistic Studies, the question was again discussed, and a series of resolutions drawn up representing a further advance towards agreement.

CORRESPONDENCE.

SIMILARITY OF CARBON AND PHOSPHORUS.

To the Editor of the Chemical News.

SIR,—In the CHEMICAL NEWS for October 23, 1914 (vol. cx., p. 210), which I recently came across, I find a letter by F. H. Loring calling attention to the close resemblance of the properties of the two elements carbon and phosphorus. This similarity between these two elements is very striking, and it is brought out very forcibly in the series of intermetallic compounds formed by these elements respectively with iron.

The well authenticated compounds formed by these elements with iron are set out below:—

Fe_3C	Fe_3P
Fe_2C	Fe_2P

The properties of the Fe_3C and Fe_3P compounds are very closely identified, and it is only with considerable difficulty that these two compounds can be differentiated when occurring together.

It is important also to note that the eutectic alloy formed by the two elements Fe_3C and Fe_3P with the saturated solutions of respectively Fe_3C and Fe_3P in iron contain the same atomic percentage of carbon and phosphorus. The figures are as below:—

Carbide Eutectic.

Carbon..	4·3 per cent
Carbon..	17·3 atoms per cent

Phosphide Eutectic.

Phosphorus.. ..	10·2 per cent (Stead)
Phosphorus.. ..	17·03 atoms per cent

The similarity in the behaviour of phosphorus and carbon is undoubtedly very striking.—I am, &c.,

J. E. HURST.

Laboratory, D. Napier and Sons, Ltd.

MISCELLANEOUS

British Industries Fairs, 1918.—As it is possible that the new accommodation for the British Industries Fair (Glasgow), 1918, may not be entirely completed by February 25th, and as it is of great importance that the British Industries Fairs in London and Glasgow should be held simultaneously, the Board of Trade have decided to postpone the opening of both Fairs for two weeks. Accordingly, the period for which the British Industries Fairs in London and Glasgow will be open will be March 11 to March 22.

NOTES AND QUERIES.

*** Our Notes and Queries column was opened for the purpose of giving and obtaining information likely to be of use to our readers generally. We cannot undertake to let this column be the means of transmitting merely private information, or such trade notices as should legitimately come in the advertisement columns.

"The Homunculus"—A correspondent wishes to know where he can either borrow or purchase a copy of "The Homunculus."

Vinegar.—Can any reader supply recipes for making pure malt vinegar and vinegar proper—that is, such as is not styled "malt" vinegar. Also the name of a book (and the publisher) dealing with the manufacture of vinegar and its by-products—to wit, yeast?—H. T.

Books Required.—Could any reader tell me how I could get the following:—"Die Technik der Rosanilinfarbstoffen" (O. Mülhäuser, 1889) and "*Derivate des Naphthalins*" (*Tauber and Norman, 1896*), or any other good books which will give me detailed information on the manufacture of phthalic anhydride and the rosaniline dyestuffs (especially fuchsine)? I should be most grateful to anyone who can get me these. Should these two books not be as suitable as others kindly advise me.—S. K.

Decomposition and Solution of Minerals.—(Reply to "Perplexed")—Your correspondent may find an answer to his query in the chapter on "Silica" in Low's "Technical Methods of Ore Analysis" (Chapman and Hall). Little difficulty has been experienced with many minerals when—(1) The substance is very finely powdered; (2) as a preliminary step before fusion, as much as possible is extracted from the mineral by HCl assisted by HNO_3; (3) any residue unattacked in the fusion is powdered up again and re-melted with fusion mixture, $Na_2CO_3+K_2CO_3$.—F. BROWNE.

MEETINGS FOR THE WEEK.

MONDAY, 21st.—Royal Society of Arts, 4.30. (Cantor Lecture) "High Temperature Processes and Products," by C. R. Darling.

TUESDAY, 22nd.—Royal Institution, 3. "Palestine and Mesopotamia—Discovery, Past, and Future," by Prof W. M. Flinders Petrie.

WEDNESDAY, 23rd.—Royal Society of Arts, 4.30. "Water Power in Great Britain (with Special Reference to Scotland), its Amount and Economic Value," by Alexander Newlands.

THURSDAY, 24th.—Royal Institution, 3. "Generalship—a Campaign of Napoleon's (1806)," by Prof. Spenser Wilkinson.

— *Royal Society.* "*Graphical Solution for High-angle Fire,*" by A. N. Whitehead. "Flocculation," by S. Pickering. "Revolving Fluid in the Atmosphere," by J. Aitken. "Ultra-violet Transparency of the Lower Atmosphere and its Relative Poverty in Ozone," by Hon. R. J. Strutt. "The Pressure in the Solar Spectrum of the Water-vapour Band λ 3064," by A. Fowler. "The Ultra-violet Band of Ammonia and its Occurrence in the Solar Spectrum," by A. Fowler and C. C. L. Gregory.

FRIDAY, 25th.—Royal Institution, 5.30. "Motion of Electrons in Gases," by Prof. J. S. Townsend.

SATURDAY, 26th.—Royal Institution, 3. "The Chemical Action of Light," by Prof. W. J. Pope.

JOURNALS WANTED.

SOCIETY OF CHEMICAL INDUSTRY JOURNAL, set; also Vol. 1 or *No. 1 (1882), or run including.* **CHEMICAL SOCIETY OF LONDON**, Memoirs and Journal, set or any portions of 1841-70. **IRON AND STEEL INSTITUTE JOURNAL**, set, or 1869-71, 1878 (Pt. 2). **QUARTERLY JOURNAL MICROSCOPICAL SCIENCE**, Nos. 122, 133, 139, 146, 147, 149, 150; £1 each offered, or buy run including. **PHILOSOPHICAL MAGAZINE**, 1881, 1888, 1891, or run. **TEXTILE MERCURY**, Vols. 1-32 (1889-1905). **TEXTILE RECORDER**, set. **TEXTILE MANUFACTURER**, set. **PERFUMERY AND ESSENTIAL OILS RECORD**, Vols. 1 to 8.

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THE CHEMICAL NEWS

VOL. CXVII., No. 3035.

THE MECHANISM OF THE SETTING PROCESS IN PLASTER AND CEMENT.*

By CECIL H. DESCH, D.Sc., Ph.D. (University of Glasgow).

ALTHOUGH the use of calcareous cements dates from a very early period of human history, and has attained to so high a development in modern times as to have given rise to an industry of the greatest importance, our knowledge of the scientific nature of the materials and processes involved is even yet imperfect, in spite of many excellent investigations covering various parts of the subject. It is convenient, in a review of our present knowledge, to distinguish between the plasters and simple chemical cements, such as the magnesia cements on the one hand, and the lime mortars, Roman and Portland cements, and similar products, on the other. The chemistry of the substances of the first group is now fairly well known, although the plasters manufactured from gypsum have proved to be unexpectedly complex, and there is little doubt that a correct explanation of the principal features of the setting process has been given. The case is different when we turn to the second group. It is only very recently that definite information as to the chemical constituents of Portland cement clinker has been obtained, and even now some points remain in dispute, whilst two distinct explanations of the setting process have been given, and the evidence in favour of either is by no means conclusive. In the present paper an attempt is made to examine these hypotheses and the evidence adduced in their support, and to indicate the nature of the observed discrepancies. The plasters are first considered on account of their relative simplicity. A short section then follows on the magnesia and similar cements, and the third section is devoted to the setting of lime mortars and the complex cements.

I. *Plaster of Paris and Gypsum Cements.*

It was shown by Lavoisier in 1765 (1) that the setting of plaster of Paris was essentially a process of recombination of the dehydrated gypsum with the water of which it had been deprived in the process of "burning," and that the strength of the mass after setting was the result of the formation of a confused mass of interlacing crystals. The mechanism of the process was not explained until 1871, when Professor H. le Chatelier (2) showed that the hemihydrate, $2CaSO_4,H_2O$, readily dissolves in water, forming an unstable solution which is supersaturated in respect to the dihydrate, $CaSO_3,2H_2O$. Any particles of the latter salt which may be present, probably in the form of unburnt particles of the original gypsum, act as nuclei, and set up crystallisation of the stable dihydrate. It is characteristic of crystals separating from strongly supersaturated solutions that they tend to grow in radial fashion about the nucleus. When the nuclei are sufficiently near to one another, the radiating needles of neighbouring groups interlock, and a mass possessing considerable mechanical strength is obtained, which can only be broken across by breaking the individual crystals. That such a supersaturated solution is actually formed is not only proved by microscopical examination, but was shown by an experiment due to Marignac (3), who shook ground plaster of Paris with water and filtered after a short interval. The filtrate was five times as concentrated as a saturated solution of gypsum at the same temperature, but it soon became turbid and deposited crystals of the dihydrate. In the ordinary setting of plaster the quantity of water is so small as to be capable of dissolving only a minute fraction of the calcium sulphate, but it is sufficient to form a layer of supersaturated solution around each particle of the hemihydrate, and when this layer deposits its excess of dihydrate the remaining water is available for the solution of a further quantity.

It is certain that the above statement corresponds closely with the main facts of the setting of plaster of Paris of the composition $2CaSO_4,H_2O$, as prepared by any of the usual technical methods. So far as the writer is aware, only one attempt has been made to explain the setting of plaster as a colloidal process. Rohland (4) has suggested that the water is taken into solution in the salt in a colloidal form, and has extended the same explanation to the caking of other salts when powdered and moistened, but the statement is not supported by evidence, and has not been accepted by others.

There are, however, certain facts which indicate that the setting process is not quite simple. It was observed by Cloez (5) that the heat evolved during the setting appears at two different stages, the initial rise of temperature on mixing plaster with water being followed by a stationary period and then again by a rise of temperature. Moreover, the density of the hydrated plaster is different from that which might be expected from the known properties of calcium sulphate and its hydrates. The hemihydrate has a density of 2·75 and the dihydrate of 2·32, and a calculation shows that the latter compound is formed from its components with a contraction of 7 per cent, whilst in practice an expansion is observed, and it is in fact on account of this property that plaster of Paris finds its application in the making of casts, the expansion enabling it to fill the mould completely, and therefore to take an impression sharply. The setting is found to be accompanied by a contraction, followed by a smaller expansion. The experiments of Davis (6) led him to the conclusion that the crystals of the dihydrate which at first separate are not identical with gypsum, but consist of a second, rhombic modification, which subsequently passes into the stable form. It may also be remarked that a part at least of the expansion is only apparent, and is due to the thrusting apart of the growing crystals, producing a porous mass. This effect is common in the growth of crystals from a supersaturated solution, and its existence is obvious from the familiar porosity of a mass of hardened plaster.

The setting of the various kinds of flooring plaster, consisting largely of soluble anhydrite, is in all probability of a quite similar character, and differs from that of plaster of Paris only in regard to velocity. The addition of other salts may also bring about great changes in the rate of hydration and crystallisation of calcium sulphate, potassium sulphate, for instance, accelerating the process and borax retarding it. Rohland has shown (7) that the accelerators are substances which increase the solubility of gypsum, and the retarders are those which diminish the solubility. Colloidal substances may delay the setting considerably, and these facts are made use of in the preparation of many technical plasters.

II. *Substances the Setting of which resembles that of Plaster.*

It was also shown by Le Chatelier that other substances which are capable of forming unstable supersaturated solutions will set in the same manner as plaster of Paris. Thus, anhydrous sodium sulphate dissolves readily in water, and if precautions are taken to prevent too rapid solution and consequent rise of temperature, a highly concentrated solution may be prepared at practically constant temperature. This solution is unstable, and the hydrate separates in characteristic interlocking masses of crystals.

Various cements composed of a mixture of an insoluble metallic oxide and a solution of the chloride of some similar salt of the same metal are in technical use. For

* A contribution to a General Discussion on "The Setting of Cements and Plasters," held by the Faraday Society, January 14, 1918.

example, a mixture of zinc oxide with a concentrated solution of zinc chloride yields a strongly supersaturated solution, from which the oxychloride slowly crystallises. Magnesium oxychloride, prepared in a similar manner, forms the basis of many cements, and may be assumed to set by a process of crystallisation, although Kallauner (8) considers that the ease with which the chloride is extracted from the solid mass by means of alcohol, and the fact that the free magnesia in the mixture cannot be completely converted into carbonate by carbon dioxide, points to the formation of a solid solution of hydroxide and chloride rather than of a definite oxychloride. A microscopical study of the setting process does not appear to have been made, although it would have some interest in relation to the problem of the dental cements, some of which have an analogous constitution.

Barium metasilicate is another salt which forms supersaturated solutions and is capable of setting when mixed with a small proportion of water. The product is the crystalline hydrated salt $BaSiO_3,6H_2O$. The orthosilicate undergoes hydrolysis, forming the hydrated metasilicate, $Ba_2SiO_4 + 15H_2O = BaSiO_3.6H_2O + Ba(OH)_2,8H_2O$. Owing to the comparatively great solubility of the silicate the setting resembles that of plaster, and the mechanical strength of the product is not comparable with that of a hydraulic cement, although in the case of the orthosilicate the chemical reaction is quite similar to that which constitutes the principal part of the hydration of a Portland cement. The product is crystalline, and consists of interlocking bunches of needles.

III. *Lime, Mortar, and Cements of the Portland Class.*

The hardening of a simple lime mortar, composed only of slaked lime and sand with water, is a mere process of desiccation. The calcium hydroxide forms an apparently structureless mass, which may be either colloidal or minutely crystalline, and the cohesion of this mass furnishes the necessary strength. The sand merely prevents the cracking which would otherwise take place during the contraction on drying, by sub-dividing the line into thin layers. As time goes on the calcium hydroxide may recrystallise to a certain extent, whilst those portions of the mass which come into contact with the atmosphere may be converted into the crystalline carbonate, but neither of these changes is essential to the hardening of the cement. There is no chemical reaction between the lime and the sand. On the other hand, when pozzolanic substances are added to the mortar, such as the volcanic earths of the Mediterranean which were used by the Greeks and Romans, the trass and ground tiles which were employed by the Romans in more northern regions, or the burnt brick and ballast added to this day in India, a chemical reaction takes place between the lime and the active or soluble silica which is the essential constituent of all pozzolanic materials, and calcium metasilicate is formed.

Portland cement is a more complex material. The constitution of the clinker has been established by the brilliant investigations of the Geophysical Laboratory staff at Washington. The compounds which are or may be present are tricalcium silicate, $3CaO,SiO_2$; calcium orthosilicate, $2CaO,SiO_2$; tricalcium aluminate, $3CaO,Al_2O_3$; pentacalcium trialuminate, $5CaO.3Al_2O_3$; and free lime, CaO (9). Campbell has recently given reasons for believing (10) that tricalcium aluminate is rather to be regarded as a *solid solution* of lime in the pentacalcium trialuminate, but this does not materially affect the present problem. Not more than three of the above-mentioned compounds can be simultaneously present in the clinker in a state of equilibrium, but since the components do not reach the temperature of fusion during the process of manufacture, it is actually possible for small quantities of one or more additional constituents to occur in commercial clinker. It does not appear, however, that clinker made in a rotary kiln departs very widely from the state of equilibrium.

An examination of the ternary equilibrium diagram shows that the clinker will contain a ternary eutectic, there being two such eutectics within the usual range of the composition of clinker. The microscopical examination of transparent sections of clinker does not reveal the presence of any eutectic, but this is simply due to the minuteness of the structure, much overlapping occurring even within the thickness of a thin section. When, however, the specimen is polished on one surface only and lighly etched, as in the examination of metals, the eutectic structure is clearly revealed. The writer has published one such photograph (11), and Mr. T. Hattori, working in the writer's laboratory, has since obtained very beautiful eutectic structure of Japanese clinker. The calcium aluminate which is chiefly present as a constituent of this eutectic is consequently in a finely divided form, and therefore in a condition to react readily with water.

According to the explanation of the setting process put forward by Le Chatelier in 1887 the ground cement reacts with water in such a way that the silicates and aluminates are hydrolysed, the staple compounds being the hydrated metasilicate, $CaSiO_3,2\frac{1}{2}H_2O$, and a hydrated tetracalcium aluminate, $4CaO,Al_2O_3,12H_2O$, the excess of lime liberated by the hydrolysis forming calcium hydroxide. Microscopical examination of the reactions of the constituents with water led to the conclusion that the process was strictly analogous with that of the setting of plaster, an unstable supersaturated solution of the basic silicate, for example, being formed initially, followed by rapid crystallisation of the stable phase in the form of radiating needles. In reference to this it should be remarked that the process is largely dependent on the ratio between solid and water, and that in hydration experiments on a microscope slide the quantity of water used is relatively much larger than in the gauging of cement in practice, and that this fact probably accounts for certain discrepancies recorded by different observers.

The alternative hypothesis was proposed by W. Michaelis in 1893 (12), and expanded in a later paper (13). On this view, whilst the chemical reactions assumed are those which were shown to take place by Le Chatelier, the physical conditions are supposed to be different. The hydrated metasilicate is considered to form, not a mass of radiating crystals, but a gelatinous mass or gel, the gradual dehydration of which brings about the hardening of the cement with time. The aluminate crystallises much more readily than the silicate; but even this is regarded as forming a gel when the solution is sufficiently supersaturated—that is when the quantity of water is small, as is the case in the practical utilisation of cement. The presence of gelatinous material at an early stage of the setting process is readily observed. It has been photographed by Stern (14), and the increase of size of the cement particles by absorption of water and consequent swelling of the gelatinous sheath which forms around them has been described by Ambronn (15), and may be readily confirmed. According to Colony (16), a reaction subsequently takes place between this early gelatinous material and the remaining constituents of the cement, and a secondary amorphous product is formed, the desiccation of which is the cause of the hardening. At a later stage crystals of calcium hydroxide, calcite, and zeolites make their appearance (17).

An attempt to distinguish between the various possible colloidal products has been made by Keisermann (18), using the method of staining with organic dyes. The results indicate that the gelatinous sheath consists of calcium metasilicates, which compound also occurs in the form of small needles, whilst the calcine hydroxide and aluminate assume the crystalline form. These staining results with colloids depend largely on the concentrations of the substances concerned, and the writer, possibly not working under precisely similar conditions, has not succeeded in confirming all of Keisermann's results. The dependence of the observations of the size of grain has been pointed out by Wetzel (19). Other experiments in which stains were used led Blumenthal to the conclusion (20) that the metasilicate and aluminate were first formed

in a crystalline condition, so that the cement sat like plaster, but that a colloidal gelatinous silicate was subsequently formed, and strengthened the mass by binding the crystals together and filling the pores.

The process of setting of the individual constituents, as well as of commercial clinker and artificial mixtures, has been examined in great detail in the laboratories of the U.S. Bureau of Standards (21, 22). The staining method has been applied as a means of identification, and the hydration has been followed under various conditions of temperature and proportion of water. The general conclusion is that the initial set is due to the hydration of the aluminates, and that the only stable hydrated aluminate is the tricalcium salt, the water content of which is variable. Either the 5:3 compound or monocalcium aluminate, if present, undergoes hydrolysis, and the tricalcium salt is formed together with free alumina, the latter separating in a colloidal hydrated form. In presence of an excess of water the product may be crystalline, as in Le Chatelier's original experiments, but with a restricted supply of water an impervious layer of the amorphous material may be formed, retarding the further action of water. The silicates are hydrated much more slowly, the products being calcium hydroxide and an amorphous jelly of hydrated silicate. The hydroxide may be crystalline or amorphous, according to the concentration and to the rate of hydration. The hydrolysis of the silicates is even considered to proceed so far that gelatinous silica is liberated (23). The subsequent conversion of a part of the gelatinous mass into crystals is considered to result rather in a loss than in a gain of strength.

It would appear that conclusions based on the examination of mixtures of ground material with water on a microscope slide must not be applied indiscriminately to the conditions of actual practice. The ratio of water to salts is of the utmost importance in determining the nature of the products, although the chemical reactions may be the same in both cases. An attempt has been made by Von Weimarn (24) to show that the passage from the colloidal to the crystalline condition is a continuous one, and that the difference consists only in a difference of size of the particles. This may be accepted in the sense of considering colloidal materials as being in such a fine state of division that the surface forces are comparable in their effect with those which depend on mass. It is then not difficult to understand that the degree of supersaturation of the solution may determine whether the product which separates shall have a definite crystalline form or shall be in the ordinary sense amorphous. The real nature of the colloidal condition has been unnecessarily obscured by the barbarous terminology which has been adopted by so many writers on the chemistry of colloids, and especially by the school of W. Ostwald. Stripped of these uncouth technical terms the study of colloids appears far less formidable, and it is to be hoped that the present discussion may, by putting in relief the views of the supporters of the two rival hypotheses as to the setting and hardening of cement, lead to a recognition of the true facts of the case, and to an elimination from the subject of the complications which owe their origin largely to a defective terminology.

A final reference should be made to the action of catalysts on the process of setting. Whilst many observations on this point are on record, the subject has not been sufficiently investigated, and affords a promising field for research. The remarkable changes in the velocity of setting which take place spontaneously in commercial ground cements, even when stored out of contact with air, are of great technical importance, and no satisfactory explanation of them has yet been given.

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IS THE SETTING OF CEMENT MAINLY A PHYSICAL OR A CHEMICAL PROCESS?*

By JOHN G. A. RHODIN, F.I.C.

MANY years ago the writer worked out a process for recovering the potash contained in orthoclase. This process, which has been described many times, involved some rather unexpected theoretical considerations. That the heating of a dry mixture of 100 parts of finely divided felspar with 40 parts CaO (dry slaked) and 40 parts of common salt to a temperature of 900° C. should involve the almost quantitative transformation of the potash in the felspar into KCl was to say the least unexpected. I took it to be the establishment of an equilibrium between the solid phase of two substances and the gaseous one of another. In my specification of 1899 I described the process as a reaction between the lime and the felspar, the NaCl acting as a "semi-volatile" flux. I also suggested that a compound resembling the zeolites was formed. Since then I have found that water vapour also plays an important part in the process, and that the resulting water-soluble salts are alkaline from NaOH. Slaked lime acts more readily than powdered unslaked calcium oxide or calcium carbonate, and the reaction between the anhydrous compounds can be facilitated by passing steam into the muffles. The necessity for calculating the amount of NaCl so as to make the resulting salt hold twice as much NaCl as KCl led to the conclusion that the proportions correspond to an equilibrium between NaCl and KCl vapours at 900° C. I hope to return to this matter at a future date, but I am now forced to confine my attention to the residue after washing out the chlorides. This is a silicate of lime and alumina, which shares with the zeolites the properties of acid solubility and capability of hydration. It hardens slowly in the air, like a very imper-

* A contribution to a General Discussion on "The Setting of Cements and Plasters," held by the Faraday Society, January 14, 1918.

fect cement, and it can be easily transformed into a good cement by heating with more lime.

Now the zeolites have another very remarkable property. If a crystal is heated so as to lose water it becomes dull and non-transparent, but it is restored to its original aspect and properties by simple immersion in water. This is to my mind closely analogous to the setting of cement, viz., the formation of a crystalline form of matter from an amorphous one by simple hydration. The physical state necessarily depends on heat treatment below the fusing-points. *Zeolites melt into a glass without any characteristic* of the original mineral. With regard to the setting of cements made from felspar residue, I have watched the phenomenon with the microscope hundreds of times. These cements being white, you can *see* the setting take place quite easily. The dull white surface alters quite suddenly, and the field of vision changes into a mass of translucent crystals in a way which gives the impression of an actual movement. These crystals adhere to one another just like the crystals in a sugarloaf. The similarity to the re-formation of zeolite crystals is quite startling.

With regard to the chemical composition of a cement, this might vary very considerably, but the physical condition is common to all cements—a condition of labile molecular equilibrium. This liability may be so great that a cement loses its cementing properties *when stored in a stoppered bottle for twenty-four hours!* Take an actual case. On August 18, 1909, I made a cement by roasting together 200 grms. of Brymbo blast-furnace slag, 40 grms. $Ca(OH)_2$, and 6 grms NaCl in a muffle at just over 1000° C. for one hour. This cement was quick-setting and very strong on the 18th; the next day, viz., the 19th, it had changed in the bottle to a nearly inert powder! I knew even then that Passau's and Colloseus' cements stored badly, but it was supposed to depend upon absorption of water and CO_2. Well, this was the beginning of a research lasting several years, but finally I hit upon a remedy. Adding quite a small percentage (0·5 per cent) of aluminium sulphate or alum before firing caused these cements to keep as well as any. Hence the impurities play an important part in cement manufacture. Why aluminium sulphate should improve a slag cement containing all the elements for its formation is a great puzzle. Be it observed, however, that it does not make the freshly burnt cement better; it simply stops it from reverting to inactive silicates. It would be interesting to know whether Prof. Le Chatelier observed this quick decay in synthetic cements. It does occur with my felspar cements, and the remedy is the same.

We can deduce from these observations that the molecules of a cement are in a state of tension, ready to break up into smaller centres, and that the speed of this breaking up can be diminished by adding substances acting in the reverse way to a catalyser. To decide whether the change is quite as great as that of colloids changing into crystalloids is rather difficult. Anyway, it is a similar phenomenon. A further argument in favour of this conclusion is the fact that fusion spoils all cements, making glassy slags, which no amount of grinding will turn into cement. The comparison with zeolites also shows a way of explaining this theory, if we consider that the loss of water leaves a spongy structure similar to the gold buttons after parting. The constancy of volume of setting sound cements is a further corroboration.

So far the actual "setting" of cements. The after-hardening is partly a continuation of this process, partly a carbonating process. It is very slow and gradual, but quite perceptible, even after a year or more. With felspar cements I have found sand briquettes increase to a breaking stress of 400 lbs. per inch, and more after twelve months, although the cement contained as little as 52 per cent CaO. As a proof of the above-mentioned preserving effect of alum I may mention the following:—Mr. Benjamin Hannen, of Messrs. Cubitt and Co., had some time ago occasion to send a sample of my white cement to the States. The only sample to be found was contained in a show-bottle, and made by me four years previously. It was found to be as quick-setting as when it was put in. The curious part is that alum affects plaster in the same way, making Keen's cement store well and quick-setting, in contradistinction to German Estrich gyps, which stores badly and sets slowly.

THE VISCOSITY OF BLAST-FURNACE SLAG AND ITS RELATION TO IRON METALLURGY, INCLUDING A DESCRIPTION OF A NEW METHOD OF MEASURING SLAG VISCOSITY AT HIGH TEMPERATURES.*

By ALEXANDER L. FEILD, B.A., M.S. (North Carolina), Assistant Metallurgist, United States Bureau of Mines, Pittsburgh, Pa.

(Continued from p. 29).

Measurements of Temperature at the Blast-furnace.

Johnson (50) has recently considered the relations of slag composition to the free-flowing temperature in the light of the melting-point determinations of Rankin and Wright (51) in their investigation of the system lime-alumina-silica. From the data of the latter investigators, Johnson has derived a diagram (52) which shows the melting temperatures of pure mixtures of calcium metasilicate, $CaSiO_3$, with an alumina content constant at 5, 10, and 15 per cent Al_2O_3, these relations having been calculated directly from the ternary diagram of the system lime-alumina-silica. In addition he has estimated the temperatures of numerous slags at flush by means of an optical pyrometer, and simultaneously has estimated by means of his eye the approximate viscosity of these slags; and has drawn, upon the basis of these observations, a curve (53) which is described by the author as a "tentative curve of free-running temperature of actual slags based on observations and pyrometer readings in practice."

In the course of the investigations described in the present Paper a number of attempts were made by the author, with the co-operation of Dr. J. K. Clement, physicist of the Bureau of Mines, to determine slag temperatures by means of a Holborn-Kurlbaum optical pyrometer, which type of instrument is the most precise one on the market, the pyrometer lamp and doubly reflecting prism having been standardised by the German Reichsanstalt and further checked and calibrated in the laboratories of the Bureau. The conclusion reached in the course of these observations was that, due to the impossibility of obtaining a clean surface on the outflowing slag and of obtaining a slag which was entirely free from fumes, such measurements, at the best, were liable to a very large error. Accordingly a special type of platinum platinum-rhodium thermocouple was constructed, the inner mechanism of the couple being protected by a sheath of Acheson graphite where subjected to the action of the molten slag. The temperature of the cold junction was noted and the necessary correction made to the readings of the galvanometer, which was of the Siemens-Halske high-resistance type (1000 ohms) and had been calibrated by means of a Wolff potentiometer. The Pt Pt-Rh thermocouple was standardised by the Bureau of Standards.

For the sake of comparison, a number of simultaneous measurements of temperature were made by means of the optical pyrometer and the thermocouple at Nos. 2 and 3 of a large steel company at Pittsburgh. For purposes of illustration a few of these results are given in Table II.

Since all optical pyrometers measure true temperatures only when the heated body is under "black body" conditions, a state from which slags at flush differ by a

* A Paper communicated to the *Transactions of the Faraday Society*. Published by permission of the Director, U.S. Bureau of Mines.

maximum amount, the optical readings of temperature at flush were discarded quite early in the course of these measurements at the furnace. Apart from the theoretical error in accuracy, such readings are liable to a very large variable error, due to differences in the nature of the slag surface and the thickness of the fume above the slag.

TABLE II.—*Temperatures of Slag at Flush by means of Holborn-Kurlbaum Optical Pyrometer and* Pt-Pt-Rh *Thermocouple.*

Date.	Flush.	H.K. Pyrometer. °C.	Thermocouple. °C.
Furnace No. 2—			
Jan. 24, 1916	2nd, am.	1487	1470
Jan. 25, 1916	3rd, am.	1487	1572
Furnace No. 3—			
Jan. 24, 1916	1st, am.	1465	1525

Further measurements were made with the thermocouple alone. Some of these measurements are given in Table III.

TABLE III.—*Temperatures of Slag by means of a* Pt-Pt-Rh *Thermocouple.*

(Date: Jan. 25, 1916).

Furnace No.	Temp. °C.
2	1515
3	1485
3	1502
3	1440
2	1415
2	1490
2	1538
3	1475

The average temperature at flush by means of the thermocouple was, on the basis of the data given in Tables II. and III., equal to 1500° C. for furnace No. 2, and 1485° C. for furnace No. 3, with a variation in temperature at flush during the day of 108° C. (the 1415° reading is omitted, since its correctness is questionable) in the former case, and of 85° C. in the second case. Both furnaces appeared to be working perfectly normally, so far as could be judged from the behaviour of the slag at flush.

Table IV. gives the analysis of the slag from both furnaces on the day upon which the temperature readings were taken.

TABLE IV.

	Furnace No. 2. Per cent.	Furnace No. 3. Per cent.
SiO_2	35·18	37·60
Al_2O_3	12·08	12·46
CaO	43·73	40·80
MgO	4·23	3·66
CaS	4·21	3·65
MnO	0·39	0·55
	99·82	98·72

The author is unable to state definitely what was the probable experimental error in the measurements tabulated above, but in the case of the thermocouple readings it was probably not more than 25° C. Accurate measurements under such conditions are extremely difficult.

An examination of the curve of free-running temperature as given by Johnson (54) shows a decided minimum at a silica content of approximately 44 per cent, this minimum free-running temperature corresponding to 2450° F. or 1339° C.

The results of the investigations of the author demonstrate conclusively that, for alumina content approximating 12 per cent, such as is assumed by Johnson, the slags of minimum free-running temperature correspond with a certain degree of approximation to a silica content of 36 per cent, rather than 44 per cent.

It is of interest to note that such a silica content (36 per cent) corresponds with average blast-furnace practice using coke as fuel.

Of course, in charcoal practice using high silica slags, it is possible to work with a more viscous slag than is the case in coke practice. However, in constructing such a curve as given by Johnson, the term "free-running temperature" necessarily refers to a temperature corresponding to a definite and constant viscosity.

Notes.

50. J. E. Johnson, jun., "The Operation of the Blast-furnace," *Met. and Chem. Eng.*, 1916, xiv., 363.
51. Rankin and Wright, *loc. cit.* (Note 49).
52. Fig. 8, p. 369, *loc cit.*
53. Fig. 1, p. 363, *loc. cit.*
54. *Loc. cit.*

(To be continued).

THE

SALINA FORMATION IN CENTRAL NEW YORK

By IRENE GORMLEY.

THE salina is the period of the Onondaga salt group, the rock from which come the salt brines of Central New York. It is quite destitute of fossils, as there was scarcely any life on account of the extreme saltness of the water during the deposition of the rock. The crystals of common salt that were embedded in the formation, long since dissolved out. give the rocks in many cases a worm eaten appearance, and so this is called the "vermicular shale."

1. The first specimen analysed was taken from a cut at the place where the Chenango branch of the New York Central Railway crosses the Erie Canal, west of Fayetteville in Onondaga County, New York. Much of the rock in that locality has the vermicular appearance referred to. It contains a larger percentage of calcium carbonate than was formerly supposed to be possible. The result of the analysis is as follows:—

	Per cent.
SiO_2	35·55
Al_2O_3	3·24
Fe_2O_3	0·90
$CaCO_3$	41·45
$MgCO_3$	48·57
Total	99·71

The specific gravity of the rock is 2·62.

2. The second specimen was taken from an outcrop on Lenox Avenue on the outskirts of the city of Oneida, New York, about twenty miles from the locality of the first specimen. The street is cut through the outcropping of the rock. It is decidedly red in colour on account of the large amount of hæmatite in its composition. There seems to be an entire absence of fossils in the locality, and there are no rocks that have the vermicular appearance. Treating the fine rock powder with hot dilute hydrochloric acid dissolves the iron, and leaves a white residue, apparently silica. There is no effervescence on the addition of acid. The analysis resulted as follows:—

	Per cent.
SiO_2	32·56
Al_2O_3	7·18
Fe_2O_3	30·49
MnO	3·69
CaO	10·46
MgO	15·76
Total	100·14

Specific gravity of the rock is 2·68.

Cornell College, Mount Vernon, Iowa, U.S.A.,
December 10, 1917.

INTERNATIONAL ATOMIC WEIGHTS, 1918.

	Symbol.	Atomic weight.
Aluminium	Al	27·1
Antimony	Sb	120·2
Argon	A	39·88
Arsenic	As	74·96
Barium	Ba	137·37
Bismuth	Bi	208·0
Boron	B	11·0
Bromine	Br	79·92
Cadmium	Cd	112·40
Cæsium	Cs	132·81
Calcium	Ca	40·07
Carbon	C	12·005
Cerium	Ce	140·25
Chlorine	Cl	35·46
Chromium	Cr	52·0
Cobalt	Co	58·97
Columbium	Cb	93·1
Copper	Cu	63·57
Dysprosium	Dy	162·5
Erbium	Er	167·7
Europium	Eu	152·0
Fluorine	F	19·0
Gadolinium	Gd	157·3
Gallium	Ga	69·9
Germanium	Ge	72·5
Glucinum	Gl	9·1
Gold	Au	197·2
Helium	He	4·00
Holmium	Ho	163·5
Hydrogen	H	1·008
Indium	In	114·8
Iodine	I	126·92
Iridium	Ir	193·1
Iron	Fe	55·84
Krypton	Kr	82·92
Lanthanum	La	139·0
Lead	Pb	207·20
Lithium	Li	6·94
Lutecium	Lu	175·0
Magnesium	Mg	24·32
Manganese	Mn	54·93
Mercury	Hg	200·6
Molybdenum	Mo	96·0
Neodymium	Nd	144·3
Neon	Ne	20·2
Nickel	Ni	58·68
Niton (radium emanation)	Nt	222·4
Nitrogen	N	14·01
Osmium	Os	190·9
Oxygen	O	16·00
Palladium	Pd	106·7
Phosphorus	P	31·04
Platinum	Pt	195·2
Potassium	K	39·10
Praseodymium	Pr	140·9
Radium	Ra	226·0
Rhodium	Rh	102·9
Rubidium	Rb	85·45
Ruthenium	Ru	101·7
Samarium	Sa	150·4
Scandium	Sc	44·1
Selenium	Se	79·2
Silicon	Si	28·3
Silver	Ag	107·88
Sodium	Na	23·00
Strontium	Sr	87·63
Sulphur	S	32·06
Tantalum	Ta	181·5
Tellurium	Te	127·5
Terbium	Tb	159·2
Thallium	Tl	204·0
Thorium	Th	232·4
Thulium	Tm	168·5
Tin	Sn	118·7
Titanium	Ti	48·1
Tungsten	W	184·0
Uranium	U	238·2
Vanadium	V	51·0
Xenon	Xe	130·2
Ytterbium (Neoytterbium)	Yb	173·5
Yttrium	Yt	88·7
Zinc	Zn	65·37
Zirconium	Zr	90·6

THE ORES OF COPPER, LEAD, GOLD, AND SILVER.

By CHARLES H. FULTON.

(Continued from p. 27).

Minerals Constituting Ores of Copper, Lead, Gold, and Silver.

THE minerals in the accompanying lists are the principal "ore" minerals of copper, lead, gold, and silver ores. They are given in the sequence of their importance. There are many more minerals containing the metals named, but they occur usually in such small quantities as to be unimportant as ore minerals.

The reader should note that the percentages of gold, *silver, copper, and lead refer to the pure mineral, not to a* mixture of mineral and impurities.

Copper Minerals.—

1. Native copper, Cu. Contains about 98 per cent *copper, and frequently a little silver.*
2. Chalcopyrite, $CuFeS_2$. Contains copper, 34·5 per cent; iron, 30·5 per cent; sulphur, 35 per cent.
3. Chalcocite, Cu_2S. Contains copper, 79·8 per cent; sulphur, 20·2 per cent.
4. Bornite, Cu_3FeS_3. Contains copper, 55·5 per cent; iron, 16·4 per cent; sulphur, 28·1 per cent. Is variable in composition,
5. Cuprite, Cu_2O. Contains copper, 88·8 per cent; oxygen, 11·2 per cent. Formed by the oxidation of sulphides.
6. Malachite, $Cu_2(OH)_2CO_3$. Contains copper, 57·3 per cent; remainder water and carbonic acid. Formed by the action of carbonated waters on other copper minerals or by weathering.
7. Azurite, $Cu_3(OH)_2(CO_3)_2$. Contains copper, 55 per cent; remainder water and carbonic acid. Formed in the same manner as malachite.
8. Enargite, Cu_3AsS_4. Contains copper, 48·3 per cent; sulphur, 32·6 per cent; arsenic, 19·1 per cent. Variable in composition; cuprous sulphide may be replaced by the sulphides of zinc and iron, and antimony sulphide may replace arsenic sulphide.
9. Covellite, CuS. Contains copper, 66·5 per cent; sulphur, 33·5 per cent.
10. Tetrahedrite, $4Cu_2S.Sb_2S_3$. Is highly variable in composition; the cuprous sulphide may in part be replaced by the sulphides of silver, iron, lead, mercury, or zinc, and the antimony sulphide by arsenic sulphide. Its copper content may vary from 25 to 40 per cent. It is frequently an important ore of silver.
11. Chrysocolla, $CuSiO_3.2H_2O$. Contains copper, 36·1 per cent; remainder silica and water. Formed by the action of hot alkaline silicic waters on other copper minerals.
12. Tenorite or melaconite, CuO. Contains copper, 79·85 per cent; oxygen, 20·15 per cent.

Gold and Silver Minerals.—

1. Native gold, Au. Contains usually some silver. Gold most commonly occurs in this form in ores.

* *Technical Paper* 143, Department of the Interior, U.S.A. Bureau of Mines.

2. Sylvanite (graphic tellurium) (Au.Ag)Te_2. Contains gold about 25 per cent; silver, 10 to 15 per cent; remainder tellurium. Composition variable.

3. Argentite (silver glance), Ag_2S. Contains silver, 87·1 per cent; sulphur 12·9 per cent. The most common ore mineral of silver.

4. Cerargyrite (horn silver), AgCl. Contains silver, 75·3 per cent; chlorine, 24·7 per cent. Formed from other silver minerals.

5. Native silver, Ag. Contains chiefly silver, sometimes alloyed with small amounts of other metals, as gold, lead, and copper.

6. Pyrargyrite (dark ruby silver), Ag_3SbS_3. Contains silver, 59·9 per cent; antimony, 22·3 per cent; sulphur, 17·8 per cent. Frequently small amounts of arsenic are present.

7. Proustite (light ruby silver), Ag_3AsS_3. Contains silver, 65·4 per cent; arsenic, 15·2 per cent; sulphur, 19·4 per cent. Sometimes a small amount of antimony is present.

8. Stephanite (brittle silver ore), Ag_5SbS_4. Contains silver, 68·5 per cent; antimony, 15·2 per cent; sulphur, 16·3 per cent.

9. Tetrahedrite, referred to under copper minerals.

10. Calaverite, AuTe. Contains gold, 41·5 per cent; tellurium, about 57 per cent. Some silver is usually present; variable in composition.

11. Bromyrite, AgBr. Contains silver, 57·4 per cent; bromine, 42·6 per cent. Formed from other silver minerals.

12. Embolite, Ag(ClBr). Contains 60 to 70 per cent silver; remainder chlorine and bromine. Formed from other silver minerals.

13. Nagyagite (foliated tellurium), $(PbAuSb)(TeS)_2$. Contains gold, 7 to 12 per cent. Variable in composition.

14. Petzite, $(Au.Ag)_2Te$. Variable in composition. Contains gold up to 25 per cent and silver up to 63 per cent; remainder tellurium.

15. Hessite, Ag_2Te. Variable in composition. Grades into petzite.

16. Polybasite, $9(Ag_2S.Cu_2S)(Sb_2S_3.As_2S_3)$. Contains 62 to 74 per cent silver. Variable in composition. Iron and zinc may in part replace silver, and the antimony and arsenic contents are variable.

Lead Minerals.—

1. Galena, PbS. Contains lead, 86·6 per cent; sulphur, 13·4 per cent. Frequently bears silver. The most important ore mineral of lead.

2. Cerussite (white lead ore, carbonate ore), $PbCO_3$. Contains lead, 77·5 per cent; remainder carbonic acid and oxygen. Formed by the action of carbonated waters on galena.

3. Anglesite, $PbSO_4$. Contains 68·31 per cent lead; remainder sulphur trioxide and oxygen. Formed by the oxidation of galena.

Zinc Minerals.—

1. Sphalerite (blende, black jack), ZnS. Contains zinc, 67 per cent; sulphur, 33 per cent. The most important ore mineral of zinc.

2. Smithsonite (dry bone), $ZnCO_3$. Contains zinc, 51·9 per cent; remainder carbonic acid and oxygen. Formed by the action of carbonated waters on other zinc minerals.

3. Calamine, $Zn_2SiO_4.H_2O$. Contains zinc, 54·2 per cent; remainder silica, water, and oxygen.

4. Franklinite $(Fe.Mn.Zn).(Fe.Mn)_2O_4$. Contains zinc, about 16 to 20 per cent. Variable in composition.

5. Zincite, ZnO. Contains zinc, 80·3 per cent; remainder oxygen.

6. Willemite, Zn_2SiO_4. Contains zinc, 58·5 per cent; remainder silica and oxygen.

Minerals Associated with Ore Minerals.

Certain other minerals are commonly associated with the ore minerals of the ores under consideration, for, as has already been noted, ores are mineral aggregates. The precious metals are frequently closely associated with certain metallic sulphide minerals. Thus gold is often found in chalcopyrite, in chalcocite, already mentioned, in pyrite, the disulphide of iron, and in arsenopyrite, the sulphoarsenide of iron. The gold is probably disseminated through these minerals in a very fine state of division as metallic or "native" gold. The mineral is then said to be auriferous, and gold-bearing pyrite is auriferous pyrite. Silver is frequently associated with galena and sphalerite, with some copper minerals, and sometimes with the iron sulphides. It is probable that it is contained as included silver sulphide, argentite, or as a more complex silver mineral. Argentiferous galena is of common occurrence.

The associated minerals may be divided into two kinds —(1) Sulphides, and (2) carbonates, oxides, sulphates, and silicates. The latter may be said to form the gangue minerals. The most common are enumerated below.

Sulphides.—

1. Pyrite (iron pyrites), FeS_2. This sulphide of iron is a very common and important mineral in ores. It frequently is auriferous, may also contain silver, and sometimes contain enough copper, probably as included chalcopyrite, to be classed as a copper ore. It is a constituent of most ores, often in considerable quantity, and in copper and lead smelting operations is the chief source of the iron required for the slag and matte formed during smelting.

2. Pyrrhotite (magnetic pyrites), Fe_7S_8 (probably). A common sulphide of iron frequently found in ores. It is seldom auriferous, but may be closely associated with copper minerals. Its significance in ores is similar to that of pyrite.

3. Arsenopyrite (mispickel), FeAsS. A sulpho-arsenide of iron. This is a common mineral in ores, and may be auriferous. Arsenic may be an undesirable constituent of ores in a metallurgical operation, but may also be recovered as a by-product, as arsenious oxide, in lead and copper smelting.

4. Stibnite, Sb_2S_3. A sulphide of antimony. Sometimes contains gold and silver. This mineral is not uncommon in ores of lead, gold, and silver, particularly in small amounts disseminated throughout other minerals, as galena. *Antimony in any form may influence decidedly* the metallurgical treatment of an ore.

Other sulphides and arsenides in ores are marcasite, FeS_2, a disulphide of iron closely related to pyrite, and leucopyrite, $FeAs_2$, an arsenide of iron.

Carbonates, Oxides, Sulphates, and Silicates (arranged in order of general importance).—

1. Quartz, SiO_2, the oxide of silicon, and closely related minerals. This mineral is almost always present in ores and makes up the bulk of many.

2. Calcite, $CaCO_2$. The carbonate of lime. A common mineral in many ores. Ore bodies frequently occur in limestone, chiefly carbonate of lime, or on the contact of other rocks with limestone. In such an ore body lime carbonate may make up a considerable part of the ore bulk.

3. Dolomite, $CaMg(CO_3)_2$. The carbonate of lime and magnesia; variable in composition. The same remarks apply as for limestone.

4. Siderite, $FeCO_3$. The carbonate of iron. A comparatively common mineral in vein deposits.

5. Rhodochrosite, $MnCO_3$. The carbonate of manganese. A not uncommon mineral in some ore deposits.

6. Barite (heavy spar), $BaSO_4$. The sulphate of barium. This mineral is frequently found as a gangue mineral in ore deposits.

7. Fluorite (flourspar), CaF_2. The fluoride of lime. A common gangue mineral in some ore deposits.

8. Kaolinite (*kaolin, clay*), $H_4Al_2Si_2O_9$. A hydrated silicate of alumina. Variable in composition; often impure. A decomposition product of certain other minerals, chiefly felspars, and often found in ores.

Other gangue minerals not so common, although in

individual deposits they may be important, are rhodonite, $MnSiO_3$, the silicate of manganese; pyrolusite and psilomelane, oxides of manganese; limonite, $Fe_2(OH)_6.Fe_2O_3$, a hydrated oxide of iron; magnetite, Fe_3O_4, the magnetic oxide of iron; gypsum, $CaSO_4$, calcium sulphate; the pyroxenes, complex metasilicates of lime, magnesia, iron, alumina, and manganese; the amphiboles, similar in composition to the pyroxenes and including hornblende, actinolite, &c.; the micas and chlorite, complex silicates; the felspar group, orthoclase, albite, oligoclase, anorthite, &c., silicates of alumina with lime and the alkalies; garnets, complex silicates; alunite, $K(AlO)_3(SO_4)_2,3H_2O$, a hydrated sulphate of alumina and potassa; and other minerals of less frequent occurrence.

In an ore, the mineral composition, aside from the contained ore minerals, may be of importance. In smelting copper ores, the mineral form in which the iron of the ore occurs, for example, whether as pyrite, or combined as a silicate, or perhaps as magnetite, may decidedly influence the metallurgical treatment. It is often of importance to know whether the silica present in the ore is there as quartz, or in the combined state as a silicate. In the milling of gold and silver ores by the cyanide process, the presence of antimony, copper, or manganese, may cause difficulties if these elements are present in certain mineral form, such as stibnite, malachite, or psilomelane, respectively, but if they be present in stephanite, bornite, and rhodonite, for example, they may have little influence on the treatment. In the cyanidation of silver ores, it is important to know the mineral in which the silver occurs, for the solubility of the various silver minerals in cyanide solution differs greatly; thus, although argentite is readily soluble, proustite is soluble only with difficulty. It follows, therefore, that a chemical analysis only of an ore is not sufficient as a guide to the proper metallurgical treatment for that ore, but it must be accompanied by the mineral analysis.

In speaking of ores, the terms oxidised and unoxidised or sulphide ores are frequently used. For the copper, lead, zinc, and silver ores the original deposition is chiefly in the form of the sulphide and of sulpho-arsenide, arsenide, or antimonide minerals, accompanied by the commonly found gangue minerals. In the upper part of the deposits, under the influence of the atmosphere and surface waters, certain of the minerals, particularly the sulphides, are subjected to oxidation, with the formation of new mineral compounds, the so-called oxidised minerals. Thus, chalcopyrite, under the influence of oxygenated carbonated waters is changed to limonite, malachite, and azurite; pyrite and pyrrhotite to limonite; argentite, by the action of surface waters containing chlorides, into cerargyrite, &c. Many ore deposits thus have two distinct zones, an upper or oxidised zone, and a lower or sulphide zone, the first being usually the smaller. Its extent is largely dependent upon climatic conditions and topography.

This change in mineral composition in an ore deposit from the surface downward has, of course, an important effect on the proper metallurgical treatment of the ore, and must receive careful consideration in the design of the metallurgical plants that are to treat the ore.

(To be continued).

First Report of the Bristol Grammar School Scientific Society, 1915—1917.—This report shows that the Bristol Grammar School is in the fortunate position of possessing an unusually flourishing scientific society. The excellent laboratories are open for practical work to the members of the society on certain evenings during the week, and in addition lectures are given at intervals. The society has a library of over 650 volumes and a herbarium of some 600 mounted specimens, and both the staff and the boys are to be congratulated upon the vigour and enterprise displayed by the members.

THE NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES, HELD IN NEW YORK.*

By THOMAS H. NORTON, Ph D., Sc.D.

(Concluded from p. 34).

Addresses and Lectures.

In addition to all the many features appealing to the eye, not only in the diverse exhibits, but also in the daily production of many admirable series of motion pictures, portraying various phases of chemical industry, the management of the Exposition provided a very extensive lists of lectures, addresses, and symposia, dealing with a large number of chemical topics of timely interest.

In most of these the patriotic note was prominent, and revealed the intense earnestness with which the American chemist faces his responsibilities during these days of strain and stress.

From the addresses the following extracts are made, as especially pertinent to the current situation or bearing upon topics connected with this section of the chemical engineer.

On the opening day Mr. Charles F. Roth, the manager of the Exposition, in welcoming the assembled chemists, called attention to the fact that chemistry had swayed the balance of power among the nations, had revolutionised warfare, and made its ends more destructive and conquests more rapid. It had, in fact, transformed the entire industrial life of the United States, and established the nation in the foremost rank of the industrial nations of the world. In closing he stated:—

"A noted German chemist once said America was the natural home of the coal-tar industry. We are proving that now, and building to make it permanently so. Not only of this industry is this true, but of all other chemical industries. Our raw materials have in the past been exported and returned to us in the manufactured form in which we used them.

"The Exposition has done and is doing much to further the development of a complete cycle of domestic chemical industries. It will this year inspire us to a greater feeling of security for the future, showing that many fields are now efficiently producing, and that we shall be in good position to not only fill all domestic needs, but to meet foreign competition in distant lands where a trade for the products of our chemical industries is already developed."

Dr. Charles H. Herty, Chairman of the Exposition Advisory Committee, followed with a stirring address, outlining the work now being accomplished by American chemists:—

"The services of the chemist to the nation in these unusual times have been prompt, efficient, and lasting. Our soldiers soon to enter battle should be protected by the most lavish use possible of high explosives. Every possible pound of high explosive that this country can produce should be manufactured and transported to the European battlefields. Trench warfare has met its master in high explosives. The terrible sacrifice of life can be lessened by the curtain of artillery fire.

"There is no time to lose. High explosives must keep pace, nay, must increase faster than our man power. When writing out my address I did it by gas-light, and I hated the thought that I was burning gas which contains toluene, every trace of which should be on its way to Europe in the form of trinitrotoluol.

"Within the ranks of that army now being formed for battling in the cause of freedom are many of our young chemists—some from the industries, some the seniors and graduates from the universities. At Princeton all are gone, at the University of North Carolina every senior

* From the *Chemical Engineer*, October 1917.

chemical engineer has enlisted. At the Massachusetts Institute of Technology the new course in chemical engineering has been abandoned until after the war, because all of the advanced men, who prepared to enter the course this Fall, have enlisted, and so it goes all over the land.

"The battle for national self-containedness in that portion of the line held by the American chemist is progressing favourably. It is not yet won, but many heights have been conquered, many formidable streams crossed, and the open plains of full national service are almost in sight. The Exposition, increasing in magnitude each year by 100 per cent of its original size, constitutes the bulletin by which the nation is informed of the progress made.

"In the centre," Dr. Herty continued, "the advance up the steep slopes of 'capitalisation' has been marked. In 1915 there was added to the chemical industries 65,565,000 dols., in 1916 99,244,000 dols., and in 1917, up to September 1, *65,861,000 dols., a total gain of* 230,670,000 dols. On the extreme right the forces of '*empiricism*' have steadily yielded ground to the advances of our research chemists. More and more called upon for utmost effort, they have never failed to respond. On the left flank a steadily increasing force of the ablest American chemists is being gathered to capture the hill of 'obsoletism of army equipment,' and is providing the great armies we are now raising with the most efficient forms of modern chemical means for both offensive and defensive warfare.

"On the right centre the terrain of 'Congressional apathy' has been partly won, as typified by favourable protective legislation for our dye-stuff industry, and by the guarding of the all-important electro-chemical industries at Niagara Falls from power shortage, due to lapsing legislation. On the left centre the quagmire plains of 'public indifference' have been largely dried and made passable through the clearing skies of a sympathetic daily press, which has constantly emphasised the value to the independence of the nation of a full-rounded chemical industry. Finally, the counter attacks of subtle propaganda against the ability of American chemists and the worthiness of our products, such as American dye-stuffs, have ingloriously failed. The optimism engendered by such splendid progress will prove, however, a curse indeed if it leads us to overlook the serious features of the present situation."

Prof. JULIUS STIEGLITZ, of Chicago, President of the American Chemical Society, in his forcible Address said:—

"Every cloud has its silver lining, and even the great black cloud of war which has been oppressing the world these three years has been penetrated here and there by bright rays of good accomplished. One of these brighter effects of the disaster, so far as this country is concerned, has been the influence of the war on our chemical industries. Facing the necessity not only of very greatly expanding their output, but also of developing many new products and of making older products of a far higher grade in quality than ever before, our American industries, as evidenced by the three great Expositions held in this place, have met and conquered one great problem after the other. We may confidently expect, and, indeed, we must insist, that out of this period of forced effort we shall emerge independent of all foreign nations in regard to our ability to supply the basic chemical needs of our country, not only in quantity but also in quality.

"As a single instance of the progress these years have witnessed in a field we must continue to hold after the war, *let me recall the dismay of our universities—and*, I am sure, also of our industrial laboratories—when early in 1915 we saw the supplies of Jena glass and of other finer glass cut off. Yet to-day we are manufacturing in the United States glassware as good as, if not, indeed, superior to the German brands we thought we never could do without. When the war is over, no matter how fierce trade competition may be, we must see to it that our new industries survive, that we do not relapse into our old dependence on European sources for almost every article in which quality, the higher quality, is essential.

"In the heat of effort of these years only the most urgent and immediate of our needs have been met. Some of these results still depend for their stability upon war conditions; they are still too liable to collapse when the world returns to its normal life and trade is free once more. In this situation, fraught with magnificent possibilities for much greater chemical achievements, but also with great dangers for the permanency of some of the American chemical industries, the American Chemical Society, for which I am speaking, sees its opportunity of being of new and still greater service to the country. Including in its membership of more than 10,000 the great majority of leading technical chemists as well as practically all the foremost men of the chemistry staffs of our universities and colleges, the Society is in a position *to render service in any branch of chemistry*, service that will be expert and at the same time judicial and unbiased *in its spirit*.

"Thus the Society, influenced by the conviction that our national welfare demands independence in dye manufacturing, was active in aiding the movement to secure a much needed measure of protection by duties on dyes.

Dr. COLIN G. FINK, President of the American Electrochemical Society, said:—

"Never before in the history of electro-chemistry has the vast importance of the various electro-chemical products been so forcibly brought to the attention of our Government and of our people as in the present year of the great war. Take from this country the electro-chemical industry with its numerous and diversified manufactures, and the martial strength of our country is hopelessly crippled. Think of the hundreds of machine shops that are utterly dependent on the electro-chemical abrasives, carborundum, and alundum! Think of the thousands of rifles and guns turned out every month with the aid of high-speed steel made from electric ferro alloys! Think of the millions of pounds of electrolytic copper that are absolutely essential for our electrical apparatus! There is the air-plane, whose light strong stays are made from the electro-chemical metals aluminium and magnesium; there is liquid chlorine, a product of the electrolytic cell and basis of the Carrel-Dakin method of treating the wounds of our heroes; there is electrolytic hydrogen, used in all of our scout and observation balloons, and there are numberless electric alloys entering into the composition of nearly every item of the Government's vast military equipment."

Prof. M. T. BOGERT, of Columbia University, Chairman of the Chemistry Committee of the National Research Council, outlined very fully and vividly the nature of the work now being done by American chemists to add to the country's effective power during the world conflict:—

"Our Committee was organised before the outbreak of the war by the National Research Council at the request of President Wilson through the agency of the National Academy of Science with the co-operation of the American Chemical Society. Its business consisted of the co-ordination of scientific activities under various Sub-Committees; a census of research chemists. Returns from this census have been *classified and indexed*, and all Sub-Committees have been furnished with lists of chemists *experienced in particular lines of work; detail of drafted* chemists to positions of value. Already more than 300 individual problems of widest range have been given careful consideration, and reports made to various departments concerning these problems. Its chief function has been to serve as a central clearing house and co-ordinating agency for the chemical research work throughout the country. It serves also as a bureau of information by which accumulated information is given wide usefulness.

It is estimated by the British authorities from their longer experience in such matters that only one suggestion in 300,000 proved to be of real usefulness. The Committee has raised funds to meet the expenses of its own activities.

"As a result of the Committee's experience to date chemists are needed in the following lines:—For teaching, the recruiting stations of the chemical laboratories being the educational institutions for the control and direction of industrial operations of all kinds; munitions, gas, metals, leather, rubber, oils, paints, &c.; for the inspection and analysis of Government supplies; to identify poisonous gases, to detect poisons in water supply; for the development of new plants and processes throughout the country, these being called for by increased demand and cutting off of former sources of supply; for small scale manufacturing operations in educational and research institutions; for the security and defence of the country by protection against the enemies' contrivances; as advisers to the Government as to the best existing knowledge on various subjects, and as to the best qualified men to initiate whatever research may be needed; in the Government laboratories to supplement the present forces. Many reagents and synthetic drugs, needed only in small quantities and therefore not of any particular interest to the commercial manufacture, are now being made in universities and research institutions just as is being done in England, and thereby are furnished materials of utmost importance for the prosecution of the war and safety of the country.

"Drafted chemists should be exempted on account of industrial needs. They are rendering just as valuable and important service as those in the trenches, and should be given insignia to indicate such exemption, as is done in France. At present there are more volunteers for research than problems to be solved. The Committee is trying simply to supplement the work of the existing Government laboratories, but the number of problems is daily increasing.

"Military power is dependent upon scientific efficiency. This was no more strikingly illustrated than by the Germans, who replaced their exhausted supply of Chilean nitrate by atmospheric nitrate. It is difficult to talk on this subject with its many ramifications at a meeting like this, so I will talk on only one or two of its phases,

"One of these is hydrogen. It may not be believed, but it is true that the balloon and the submarine are problems in common. There is the necessity of analysing the hydrogen used in inflating balloons for the discovery of foreign matter likely to be detrimental to the balloon's fabric. Then there is the development or creation of static electricity in the fabric of the balloon. That is another thing the chemist has to look out for.

"American chemists have devised two automatic hydrogen detectors and turned them over to the Government. The purpose of these detectors is to warn the submarine crew of the escape of chlorine gas from the storage batteries.

"The first gas attack was made by the Germans on April 15, 1915. Within four days after this first attack the Allies had equipped 3,000,000 men with temporary gas masks.

"At the present time there are 15,000 workers in England alone engaged in making masks for the military forces. They are turning out 20,000 masks a day, while contracts had been made for 25,000,000. One hundred and fifty chemists in this country are working on the gas-mask problem for the American soldiers."

Dr. L. H. BAEKELAND, in an Address upon "The Future of the American Chemical Industry," brought out many important points:—

"We have carried the mass production of synthetic explosives to a point never dreamed of. With truth, it can be said that if it were not for one of our largest chemical manufacturing companies, which promptly rushed to the rescue of the Allies at the beginning of the war and furnished them with explosives of which they were short, the war might have been ended a year ago in favour of Germany.

"Since then the chemists of France and England also have shown abundantly what they can do when conditions require it, and everything points out that after this war is over the supremacy of Germany in some of the chemical industries in which she heretofore was a leader will be a thing of the past.

"As far as the mineral chemical industries are concerned this country, even before the war, could stand excellent comparison with Germany or any other country. In fact, when it comes to the production of acids and heavy chemicals, the United States in several of these branches was decidedly ahead of Germany. There is no doubt, however, that we were behind in the manufacture of synthetic organic chemicals, which include the coal-tar dyes. But there was nothing strange or abnormal in this situation. The importation of these products in the United States before the war did not exceed 10,000,000 dols. a year, this covering more than 1000 different kinds of products, all of which require special processes of manufacture, and some having to be worked in very small units. As a business proposition there was little to attract shrewd American business men.

"If Germany specialised in this branch of chemical industry, it was merely because she did not have the same opportunities for enlisting in other fields of enterprise. In this country we had new mines to exploit, new fields to cultivate, new railroads to construct, and many more industries of immediate importance claimed the full attention of our men of enterprise or scientific training. No wonder, then, that a little paltry industry of the kind was neglected.

"Nevertheless, as far back as the early seventies, a few enthusiasts started the manufacture of aniline dyes in the United States. They were making quite some headway, but in 1883 they had to perch through unfavourable tariff legislation. At that time German agents were already at work in this country, and were leading our textile manufacturers by the nose, and they helped them in their lobbying for the lowest tariff on dye-stuffs, claiming that Germany would serve them, furnishing them with what they called their 'raw material.' This situation acted as a boomerang and paralysed out textile industries at the beginning of the war.

"Since then this country has realised that we must not estimate the value of the colour industry in dollars and cents, but by the direct bearing it has as a key to all other industries. A few cents' worth of the right kind of dyes decides whether a hundred dollars worth of textiles can be sold or not in the open market. What is most extraordinary, almost a wonder, and bears witness to the flexibility and adaptability of American enterprise, is that in less than three years we should have made ourselves independent of Germany in the line where she had the start on us since half a century.

"The steady development of our industries of heavy chemicals, in the mineral or inorganic line, will very probably proceed as in the past. America's greatest development will consist in the further extension of industries in the organic field.

"In a country blessed beyond comparison with all the necessary natural resources for a large chemical industry, with a home consumption greater than that of any other country, are very short of cheap water powers. Our great development of the electro-chemical industries in the United States was due to the fact that for the first time we placed at the disposal of our industries abundant electrical current, at lower rates than it has been obtainable in the past by means of steam. We became the leaders in those industries. Niagara Falls and its industries became a by-word of electro-chemical supremacy throughout the world. Since then all other countries have gone us one better in the production of cheap water power.

Unless we change our present condition, it looks as if our electro-chemical industries, our leading chemical industries, were going to be wrested from us to find a more inviting home in Canada and in Norway. Unfortunately, here again the condition is one of 'dog-in-the-manger' politics. A hydro-electric plant as a Government enterprise would not involve much of a new departure as compared with that splendid example of good engineering, the Panama Canal."

Mr. W. S. Kies, Vice-President of the National City Bank, told of the development of the American export trade in chemicals:—

"The capital invested in chemical production from 1880 to 1915 has increased about eight times. The number of employees in the industry during that period increased but a trifle over three times, and the wages and salaries paid increased about five times—from 6,000,000 dols. to 31,000,000 dols. In 1914 the chemical industries of this country exported in round numbers chemicals, drugs, and dyes to the amount of 27,000,000 dols. In the fiscal year, 1917, these exports amounted to 185,000,000 dols. In explosives the value of our exports grew from 6,000,000 dols. in 1914 to 820,000,000 dols. in 1917. Under the heading 'other explosives' the value of our exports grew from 1,000,000 dols. in 1914 to 420,000,000 dols. in 1917, showing that in the industries closely allied with chemicals the growth has been quite as striking as in chemicals proper."

Dr. B. C. Hesse dwelt upon the relations of the tariff to the manufacture of coal-tar chemicals:—

"There are not a few products of even the coal-tar chemical industry in which an import duty may in effect become a premium on inefficiency in operation and management, particularly in those cases where the costs of the basic materials employed are substantially the same at home and abroad in such cases, after the manufacturing technique has been acquired and a degree of efficiency in operation and utilisation fairly comparable with the maximum has been achieved, the sole disability to the foundation of the industry will have been removed, and domestic makers should then be in position to compete on those goods with foreign makers in our own markets without any artificial help through protective import duty, and thus give these articles to such of our other domestic industries as use them at prices equal to those anywhere.

"In order that too much time be not taken in getting going, the conditional five-year limit to the life of the sur-tax of 5 cents per pound on certain dyes and of 2½ cents per pound on intermediates was obviously inserted in the present dye and allied chemicals tariff, which, in my opinion, is a very wholesome and a very equitable spur to our domestic manufacturers."

Mr. G. A. O'Reilly, of the Irving National Bank of New York, spoke upon "Chemistry and the Banker":—

"The true relation of banking to chemistry is found in the theory of practical everyday business. This theory must be taken seriously and literally by both banker and chemist if they are to derive the greatest benefit from each other and from business. Regardless of tradition and of personal inclination, they must descend from their respective pinnacles, whether of financial exclusiveness or scientific preoccupation, and get together in the intensely practical and really very comfortable atmosphere which the thoroughly up-to-date business man of to-day has created and prepared for them. If in doing this it becomes necessary to disturb an occasional delightful fiction or to smash an occasional professional idol, it is believed that both may be done to the entire benefit of all concerned.

"The theory that the true relation between chemistry and banking is found in business finds considerable justification even in conditions existing before the war. When viewed in the light of the big wonderful new things which war has brought into the world, the conclusion becomes irresistible. The indifference with which in former years private interest viewed national problems and difficulties finds but slight resemblance in the magnificent response which business everywhere has made to the nation's call.

"And so while considering the business relationship between chemistry and banking we should concede sufficiently to the business advantages which will result to both from a proper getting together, we must not lose sight of the fact that the big thing in this relationship will be the national interest. For us there are just two worth-while things in the world to-day—one, to win the war; the other, to protect American interest afterward. Naturally, winning the war comes first, but preparations to that end should be definitely based upon the understanding that wars are to be won principally that nations may live in greater peace and security and prosperity afterward."

Dr. Arthur D. Little, of Boston, the well-known chemical engineer, dwelt upon the same theme:—

"The formation of indigo in the plant is a chemical reaction no less than when indigo is made by synthesis in the laboratory. Bankers were not particularly interested in the laboratory work until it became a commercial success, whereupon they began to take a decided interest in the credit of the indigo planter. Agriculture, which is so fundamental to the well-being of any country, depends very largely upon chemistry, which makes possible fertilisers, furnishes data upon which methods of civilisation may be based, and revises methods for the utilisation of what would otherwise be an absolute waste. For example, the utilisation of cotton-seed has added more than a hundred million dollars annually to the value of the cotton crop, and cotton itself has become the raw material for very diverse chemical processes of the highest importance, such as explosives, celluloid, lacquers, and other well known items of commerce.

"The chemist is made to feel that he speaks a foreign language when talking to the banker, but events of the last three years are changing that. The flying corps risks its life daily solely for the advantage of a different viewpoint. The banker is in as great need of a new viewpoint, and can avail himself of it very much easier and without such risks. The waste that the chemists see on every hand really hurts, but it seldom moves the banker. The chemists through the prevention and utilisation of these wastes could doubtless do more than any other profession in paying the debts of the war. This certainly should interest the banker. Of scarcely secondary interest is the chemistry of insurance, and the work which chemists can do in preventing the great annual fire losses. If Niagara Falls ran coal instead of water, how long do you suppose it would be maintained for the sake of a spectacle, and yet great obstacles have been placed in the way of the chemical engineer who would utilise Niagara's energy more fully than at present without seriously endangering the spectacle."

Dr. Little, on another occasion, discussed the dye-stuff situation:—

"Roughly speaking 75 per cent of the dye-stuffs needed are made in this country, and of this three-quarters, some are made in such excess that a considerable export trade is carried on with friendly countries, especially England.

"Of others needed there is a shortage, and this is serious in such basic colours as magenta, methylene blue, auramine, methyl violet, and a few more. The prices of many of them are way up, which has lured into the business a number of minor concerns in which the art is lacking to secure adequate yields. Some also are under incomplete chemical control, and they fail to purify their materials properly. This is incidental to pressing need and hasty establishment which the whip of time will correct. On the other hand, the very highest praise should

be awarded to the conscientious manufacturers who have strained every nerve to meet the country's needs, often at the expense of profit.

"We have then three-quarters of the dye-stuffs needed, some aplenty and others scarce. In regard to quality, American-made dyes are the same as German dyes, only *there are not* so many of them. If some small makers are still short in their yields the loss is theirs. If they do not purify their materials enough the defect is more likely to be in shade than in fastness. This is a complete catalogue of the defects of American-made dyes and it does not apply to the products of the important makers. Nevertheless, dyers have been sorely put to it. They have had to use one material when they wanted another, and the substitutions have often been unhappy. They have also been compelled to relearn the art of using dyewoods for many purposes which are new to the present generation, and this is not to be learned in a day. The trouble, however, has principally come from the makeshift substitution of wrong materials for the right ones, because the right ones are lacking. The colours themselves are the standard articles whether made in Germany, France, Switzerland, England, or here. And missing and scarce products are coming upon the market as agreeable surprises at short intervals."

H. Gardner McKerrow dwelt also upon the same topic:—

"In point of quality American colours will, for the most part, compare well with the best imported colours. Both as regards brilliancy, fastness to washing and light, and general wearing qualities, the new styles are fully equal to the well known German type, as indeed there is no reason why they should not be, for the making of a dyestuff is, *given the requisite intermediates* of good quality, simply the following out of a fixed formula and the carrying out of certain prescribed successive steps.

"The industry is well established, and there is no longer any fear of a shortage of dye-stuffs, or a shutting down of factories on an account of an absence of colours, and the new fashions are showing as much variety and brilliancy of shade as ever. It is true that some of the more delicate and fancy shades are not yet obtainable in American-made dyes, and it may be some time before these are forthcoming, for the simple economic reason that they are used in comparatively small quantities and only by certain specialised industries, such as certain kinds of silk manufacture. Doubtless these specialised manufacturers feel themselves aggrieved because their needs are not among those which have been filled, and are inclined to say dyestuff manufacturers, like all others engaged in undertakings which are primarily expected to be profitable, will naturally tend to produce those commodities which are in the most general demand and in the largest use. Whether our newest addition to the industrial accomplishments of the country continues to live and thrive after the war is over, and when, presumably, we shall meet with the desperate competition of interests which are struggling to save for themselves the remnants of trade life which have been left to them, depends on two things—a proper degree of protection against dumping and undervaluations of imports, and an earnest and patriotic co-operation on the part of our manufacturers and colour users themselves."

Oil in the United States.—The principal oil producing States in America are California, Oklahoma, Illinois, West Virginia, Texas, Louisiana, Ohio, and Pennsylvania. Over 33,500,000 barrels of fuel oil, according to the *Engineer*, are annually consumed by railways. The total yearly oil production of the United States is about 222,500,000 barrels of 42 gallons, and is furnished by the six great fields and a few scattered states. The greater part of the oil produced from the Gulf and Californian fields is consumed as fuel.

NOTICES OF BOOKS.

The Training and Work of the Chemical Engineer. London: The Faraday Society. Pp. 60. Price 3s. 6d.

This pamphlet contains a full report of a general discussion held by the Faraday Society, and is reprinted from the *Transactions*, vol. xiii., September, 1017. The introductory address was delivered by the Chairman, Sir Robert Hadfield, F.R.S., and various aspects of the subject were put before the audience in papers by Sir George Beilby, who opened the discussion, Prof. F. G. Donnan, and others. Schemes of work were outlined in these papers, and many criticisms and suggestions were made. Many eminent men took part in the proceedings, and stress was laid upon the need for reforms in our educational system, beginning at the bottom. The consensus of opinion was decidedly in favour of adequate training in both chemistry and engineering, and in giving students access to works where they may learn how to understand and handle men. It is looked upon as essential that men of large scale practice should help in teaching and managing at the Universities, and that University laboratories should have possibilities of teaching students to carry out chemical processes on the scale of a small experimental plant.

MISCELLANEOUS.

Le Cercle de la Chimie.—A society entitled Le Cercle de la Chimie has recently been founded in Paris, the offices being situated at 54, Rue de Turbige, Paris, 3e. The obect of the society is the bringing together of chemists, engineers, manufacturers of chemical products, &c., *to enable them to discuss matters of common interest*, and to keep themselves informed of the developments of science, and in particular of the chemical industries in France. *The Revue des Produits Chimiques*, published at the above address, will be the official organ of the Society.

NOTES AND QUERIES.

*** Our Notes and Queries column was opened for the purpose of giving and obtaining information likely to be of use to our readers generally. We cannot undertake to let this column be the means of transmitting merely private information, or such trade notices as should legitimately come in the advertisement columns.

Books Required.—(Reply to S. K.).—It is highly improbable that the volumes can be purchased at the present time. If, however, S. K. is a Fellow of the Chemical Society he would be able to borrow them from the Library under the customary regulations.—F. W. C.

MEETINGS FOR THE WEEK.

Monday, 28th.—Royal Society of Arts, 4.30. (Cantor Lecture) "High Temperature Processes and Products," by C. R. Darling.

Tuesday, 29th.—Royal Institution, 3. "Palestine and Mesopotamia—Discovery, Past, and Future," by Prof. W. M. Flinders Petrie.

Wednesday, 30th.—Royal Society of Arts, 4.30. "The Manufacture of Margarine in Great Britain," by Sir William G. Watson, Bart.

Thursday, 31st.—Royal Institution, 3. "Illusions of the Atmosphere—Revolving Fluid and the Weather Map," by Sir Napier Shaw.

— Royal Society. "The Growth of Trees," by A. Mallock. "Action of Light Rays on Organic Compounds and the Photo-synthesis of Organic from Inorganic Compounds in presence of Inorganic Colloids," by B. Moore and T. A. Webster. "Isolation and Serological Differentiation of *Bacillus tetani*," Capt. W. J. Tulloch. "Investigation into the Periodicity of Measles Epidemics in the different Districts of London for the Years 1890-1912," by J. Brownlee.

Friday, Feb. 1st.—Royal Institution, 5.30. "Gravitation and the Principle of Relativity," by Prof. A. S. Eddington.

Saturday, 2nd.—Royal Institution, 3. "The Ethics of the War," by M. P. H. Laysop.

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THE IDENTIFICATION AND ESTIMATION OF LEAD IN WATER.

Part I.

By ROBERT MELDRUM.

The following investigation was undertaken to examine into the sensitiveness and reliability of the hydrogen sulphide and potassium chromate colorimetric methods for the detection and estimation of lead in water. Both processes are in general use with considerable variations in procedure and manipulation according to the ideas of each individual operator. Failure, therefore, to discover lead when present, or seriously under or over estimate it, is mainly due to important details in manipulation being not fully recognised or overlooked. As both methods are purely comparative it is generally assumed that equal proportions of reagents + equal conditions + equal lead contents with variable waters will give equal intensities in coloration. But so far as the author's investigations go this has been found to be the case, but only as regards the same kind of water. It will be shown that different waters with equal lead contents, with the H_2S process, give unequal coloration intensity. It will also be shown that with the same water at variable lead dilutions with slightly excessive ratios of reagents that the resulting coloration for any specific lead dilution is also not constant as regards the H_2S process. No sample of water which has passed through the author's hands has gone astray from this general behaviour. At this stage it is considere desirable to give in detail a description of the H_2S method in use by the author, which is based on the experimental data to be afterwards described, which of course is applicable to the general testing of waters for lead by the H_2S process.

The H_2S Colorimetric Process.

The Standard Lead Solutions.—This is best prepared by dissolving 1·831 grms. pure normal lead acetate in about 100 cc. distilled water, adding a few drops of acetic acid to dissolve the lead carbonate formed, filtering into a 100 cc. flask, and making up to the mark after filter is well washed with acidulated distilled water. This solution will contain 0·001 Pb per cc. From this a weaker solution containing 0·0001 Pb per cc. is prepared by dilution when required. It will be necessary to determine the Pb in the acetate or in the standard by precipitation as $PbSO_4$ as a check on the purity of the acetate. Normal lead acetate as purchased cannot always be depended upon for normal Pb, due to variation of crystal water present or to basic lead acetate or lead carbonate. Five grms. of the acetate is a conveniently large portion to weigh out for the lead determination. The acetate, if actually normal, ought to contain 54·353 per cent Pb, and the standard corrected for any deficiency or surplus found.

The standards must be stored in lead free glass bottles, and on shaking must remain clear, bright, and free from all traces of cloudiness and suspended matter, and contain no deposit at bottom of bottle. Should at any time a cloudiness appear in the standard a few drops of acetic acid ought to be added and well shaken; but should, however, a cloudiness or deposit persist the standard is not fit for use. In particular these remarks apply to the weak lead standard, which under the best conditions cannot be kept in good condition for many days due to bacterial and fungoid growths and to matter dissolved from the glass. This suspended matter is frequently of a flocculent nature, which will not dissolve in acetic, and in which the lead appears to be highly concentrated. The result is that this matter gives, when added to the standard test water, floating or suspended particles of PbS which ought to be in solution as PbS. It is, therefore, of importance to examine all lead standards carefully before use.

All lead standard solutions, especially when containing only 0·0001 Pb per cc. on prolonged keeping undergo depreciation, due to the absorption of H_2S, NH_4HS, SO_2, and NH_3 fumes, even in traces. The standards, therefore, ought to be preserved in capped stoppered bottles in a pure atmosphere.

Pouring out the standard from the bottle into a burette or other measure cannot be considered satisfactory, as the lead concentrates around the stopper and lip of bottle. It is more satisfactory to withdraw the solution by means of a good pipette. The best plan to adopt is to withdraw 25 cc. of the stronger standard and place in 250 cc. flask and make up with distilled, and use a 5 cc. graduated long stemmed pipette for withdrawing same. A cork is fitted to pipette, which rests on neck of flask. Even graduated pipettes of 2 cc. divided into 50 or 100 parts may be used if desired, or when necessary.

H_2S *Solution.*—This ought to be freshly prepared, or at most three days old, and of maximum strength. In any case it ought to be bright, clear, and free from suspended sulphur, H_2SO_4, H_2SO_3. This is best contained in a 50 cc. bottle of lead free glass, to which is fixed a cork with a 1 cc. long stem pipette attached.

Acetic Acid Solution.—This is the only acid suitable for acidifying as no coloration will take place at extreme lead dilutions with HCl, or H_2SO_4, or H_2SO_3. A convenient strength to use is 20 per cent glacial acid by volume to 80 per cent distilled water. The acetic acid must of course be lead free and tested with H_2S and coloration if any compared with distilled water. This must be kept in lead free glass bottles with a 1 cc. pipette attached as with the H_2S solution.

Apparatus, &c.—The following is a list of the minimum and simplest apparatus required for general testing purposes, which answers equally well for the H_2S and chromate methods. But to save time and delay and trouble the apparatus may with great advantage be duplicated or trebled.

1. Two 100 or 50 cc. bottles with two 1 cc. pipettes fixed.
2. One 5 cc. long stem pipette divided into tenths.
3. Three graduated 100 cc. cylinders of best colourless glass.
4. Or three Nessler tubes with stopcocks—100 cc.
5. Three 50 cc. graduated cylinders same diameter as 100 cc.
6. Three glass rods 12 inches long with flattened ends as mixers.
7. Sheet of white thick blotting paper.
8. Porcelain tile 12×12 inches, or porcelain plate or tray.
9. 10 cc. burette stoppered divided into tenths.
10. An accurate 25 cc. pipette for making standard.
11. A clean bottle or burette brush to fit test cylinders.

The apparatus becomes more complex, especially as regards the illumination, where special work requires to be undertaken as regards the action of various waters on lead under various conditions, but it is not necessary to go into these at present.

The Sample.—The sample of water to be tested is well shaken and carefully examined in a *good* light for any traces of cloudiness, suspended matter, or deposits adhering to bottom of bottle. The fact is most frequently overlooked that lead when present often exists in suspension, or as a deposit at bottom of bottle. The sample is well shaken after removing all adhering deposits by means of a long glass rod with a rubber end. 100 cc. are drawn off and acidified with 1 cc. 20 per cent acetic acid and filtered into graduated 100 cc. cylinder, which portion is used for determining the total lead in solution and suspension. To obtain the lead in solution it is only necessary

to filter the water without adding any acid into another 100 cc. cylinder. The results are expressed as Pb in solution + Pb in suspension = total Pb.

The sample must be examined for colouring matter against distilled water, which can be done with one of the above portions. The colouring matter present may usually be estimated as compared with cc. lead solution in distilled water required to match it. The colour of many waters may be matched in this manner. The cc. lead solution used to produce equality of tint is deducted from the total cc. lead solution required in the Pb estimation. This will only be necessary when the water colour is high and distilled water used for the standard. In some cases it is not possible to match the natural colour of the water by this means, and other substances such as caramel solution or peat extract used instead.

It is essential to test the glass bottle containing the sample for lead. This can only be done by emptying the contents and washing well with a bottle brush, and finally cleaning with a 1 per cent solution acetic acid and well washing with distilled water. Fill the bottle with 500 cc. distilled and 10 cc. strong acetic and allow to stand twenty-four hours and test for Pb. When the bottle cannot be emptied in this way the test may be made by cleaning the outside of bottle and immersing the base in a basin with the acidulated water and performing the test. The application of this test is imperative when the nature of the glass is unknown.

The Blank Experiment.—It is essential, more especially with new apparatus, to test the graduated cylinders, pipettes, and reagents for lead. This is best done by washing out all the cylinders, pipettes, and test glasses with HCl, tap and then distilled, and filling all with distilled and adding 1 cc. 20 per cent acetic and well mixing with glass rod mixers, and allowing to stand for an hour with the glass rods in the cylinders. Now add 1 cc. H_2S and compare with cylinder full of distilled water only. The blank is considered satisfactory if no trace of coloration develops in two minutes.

The Process.—100 cc. of the sample which is suspected to contain Pb is placed in one of the cylinders and 1 cc. acid added, and well mixed and put aside for two minutes. 1 cc. H_2S is added and again well mixed. This is compared with another 100 cc. of the sample or distilled water without any reagents being added. The least trace of coloration will indicate the presence of either copper or lead. The presence of copper is detected by testing another portion of the sample with ammonia, and if present the lead must be identified and estimated by the chromate method to be hereafter described. As the ferrocyanide test for copper also gives a reaction with zinc and iron and lead, brown, white, and blue tints respectively result, which, if all be present, will, more or less, make the test very indefinite. It is therefore better to use ammonia for identifying the copper. It is also well to remember that zinc in acetic acid solution is also precipitated by H_2S, which causes a turbidity when present to the extent of 1 in 100,000 or more. The zinc, therefore, only becomes troublesome by obscuring the brightness of the lead sulphide coloration. Should this obscurity persist by the presence of zinc the lead will require to be estimated by the chromate method. However, by adding only 1 cc. H_2S or 0·75 cc. no turbidity will result from zinc, even when present to the extent of 1 in 100.000.

The lead is estimated by comparing the intensity of coloration resulting from the addition of H_2S to the lead-contaminated water, with a sample of the same water but free from lead, to which is added lead standard solution to produce equal intensity of coloration. The most convenient and reliable way to do this is to take 100 cc. of the sample, add acid and H_2S, and compare with 100 cc. of the lead-free sample, to which is added 1 cc. acid, and lead solution till equally approximate tints are obtained. Then take a fresh 100 cc. and add to this the cc. lead solution found as above, add acid and H_2S, and compare. A slight difference in tint should only result, which may be reduced to equality in colouring by lowering one cylinder or the other, and the respective values found. It is well to remember that during the final coloration measurement both columns ought to be as near as possible of the same height, otherwise low or high results will ensue. There ought not to be more than 10 cc. difference between the columns at most, and if more than this a little make-up water ought to be added. The point to remember is that the lead ought to be estimated at the actual concentration present in the water, and no dilution method ought to be used, but the estimation made with shorter, say 50 cc. cylinders, instead.

The Colour Measurement.—The tint estimations are made near a well-lighted window or by means of oil, gas, or electric light. A good white light is necessary. That from an ordinary cycle actylene lamp, or good oil lamp, are both satisfactory. Gas mantle jets also give good results. Metal filament and carbon film electric lamps require screening with oil paper, or sand blasted or opaque glass globes, otherwise reflection effects cause trouble. It is a great convenience to have a lamp which can be lowered, or moved towards the observer at will and where the candle-power can be increased if desired, or lessened. A good acetylene light or powerful oil lamp answers all requirements. Such a mode of illumination will be found most useful when the lead exceeds 1 part per 100,000, as the density of tint may require powerful illumination unless dilution is resorted to. Again, when traces of lead are only present the illumination requires to be subdued.

The test mixers or cylinders are covered with two or three folds of stout blotting paper, which are fixed with rubber bands, leaving the bottom uncovered. The cylinders must always be kept dry on outside, and the paper jacket also, otherwise reflection effects will obscure the reading. By using these paper jackets, brighter, stronger, and purer tints are obtained, which are essential for making a true colour comparison. Unless the cylinders are so screened, colour comparisons in the majority of waters become impossible, unless tintometers or colour meters are used. The paper jackets ought to be continued above the 100 cc. mark.

The glasses are placed on the white tile and during colour comparison are raised about one to two inches, with the light adjusted to fall on the plate, and the candle-power increased according as the depth of tint increases. Under these conditions, 1 part Pb per 4 million parts may be detected and estimated with a 7-inch or 100 cc. column. This is equal to 0·025 part per 100,000 or 0·0175 grain Pb per gallon, which is the limit of the test. With 200 cc. or 14 inch columns 1 part Pb in 8 million parts may be detected, or 0·0125 part per 100,000, or 0·0067 grain per gallon, which is more sensitive than the chromate test.

When the Pb present exceeds 0·75 part per 100,000, on looking down the tube a semi black reflecting surface only is visible, which is almost opaque to ordinary daylight. At this and greater Pb concentrations vertical colour comparisons cannot be made with the full 100 cc. column. In such cases it is advisable to work with 50, 40, or 25 cc. columns, measuring on a vertical line of sight, or better still, to measure the tint on a horizontal line of sight right throught the tube. In these cases the paper jackets must be dispensed with. Even when the Pb is present at the rate of 5 parts per 100,000 the horizontal method may be used, but using carbon estimation tubes in place of the cylinders. By this means the estimations may be conducted without resorting to dilution of the sample.

Summary.—Due to the colouring matter in the water sample, and also its saline constituents and other unknown factors, no estimation of Pb in water by the H_2S process can be considered satisfactory unless a sample of the lead-free sample water is used as standard. As previously stated, the reason of this is that different waters with the same Pb contents give with H_2S variable intensity of tint, amounting in some cases to 100 per cent. When distilled water is used for the standard, the lead is likely to be underestimated by 25 to 33 per cent at least, if not more.

THE SETTING OF CEMENT IN ITS RELATION TO ENGINEERING STRUCTURES.

By BERTRAM BLOUNT.

THE question of the setting of cements of all sorts has been a subject of investigation for many years, and except in the simple case of plaster of Paris remains unsettled. As there are many contributors to this discussion who have devoted great attention and much work to the endeavour to decide the true causes of setting, and as at this meeting they will formulate their views, I propose to deal chiefly with the practical aspect as it appears to the engineer.

Before doing this, however, I should like to say a word or two on the present state of the theory of the subject.

In the first place the term cement is elastic, and it is wrong to suppose that colloids like casein should be excluded. Their behaviour may throw light on the mechanism of setting of more important cements. Next how is one to define setting? Generally it involves hydration, but is the induration due to loss of water, as in the case of clay, to be excluded? I take it that, broadly, setting does not connote hydration, and with this narrower definition we must be content. Taking the typical case of plaster of Paris, it has been established that a supersaturated solution is formed, that interlocking crystals are deposited from it, and that the released water passes on to perform the same function with adjacent particles. This naturally leads to a consideration of whether strontium sulphate and barium sulphate set in the same way. The low solubility of both, especially the latter, would seem at first glance to negative the supposition, but as both are found crystalline in nature the question is not superfluous. Coming to industrial cements of the Portland cement class the question is much more difficult. I am not aware that any definite proof has been given that the constituents of Portlant cement form supersaturated solutions and set in the manner accepted as true for plaster of Paris. A fair indication of this is found in the fact that there are two schools of thought concerning setting, the one crystalline, the other colloidal. I profess myself strongly neutral, as evidence on each side appears inconclusive, but it may well be that in this discussion the whole matter will be cleared up by those who have had more recent opportunities of experiment than I.

Such theoretical considerations lie at the very root of the matter, and when they have been determined will be as complete a guide to practice as the principles of mechanics are to the design of a bridge. Until this end has been accomplished we must be content with humbler empirical methods.

As setting is a gradual process there is no such thing in reality as a setting point or setting time. But in practice it is convenient to fix an arbitrary condition which is called the "setting point," and to call the time occupied in reaching this condition the "setting time." With minor cements, such as those of the plaster of Paris class, it is not usual to define the condition or the time rigidly. It is generally sufficient to recognise that ordinary plaster of Paris "goes off" quickly and needs rapid handling, and that other calcium sulphate cements setting more slowly can be manipulated in a more leisurely way and require a considerable time to harden. With the more important cements, of which Portland cement is the chief instance, something less rough and ready is required. In consequence numerous methods have been devised and put into tentative use. One of the most mechanically attractive was that of my friend Prof. John Goodman, who in 1887, as far as I remember, constructed a machine consisting of a metal trough on which ran a loaded roller pulled by clockwork and having a central fin. The trough was filled with cement and the ends of the roller rolled on the edges of the trough with the fin dipping in the plastic cement. As the cement set, and the roadbed became harder, the fin with its roller was gradually lifted upwards and eventually rode on the surface of the set cement. The rate and time of setting were automatically recorded on a diagram drawn by a pencil passing through the centre of the roller. Certainly a neat idea, but the difficulty common to all methods of determining setting time came in. There was no definite point of time when the fin on the roller ceased to make an impression, and thus the accuracy aimed at by this ingenious machine was greater than the nature of the material allowed. I hope that Prof. Goodman will correct me if I am wrong, as I write from memory.

In practice the only apparatus of any value for determining the setting time of cement is the Vicat needle—or one of its modifications, such as the British standard needle formerly used—which is too well known to need description. By simple means of this kind cements can be classified quite as closely as their nature allows, having regard to the fact that the setting of cement is not like the setting point of a metal—and that too is a progessive phenomenon but a gradual process.

Even with this modest standard of attainment the determination of the setting point of cement is beset with pitfalls. Cement is scarcely ever used neat, and yet its setting point is invariably determined neat, and I for one see no means of using any other method. The best that can be hoped for is that a cement with a given setting time will behave with some sort of relation thereto when it is made into mortar or concrete. But consider the difficulties here. An ordinary Portland cement will require about 22½ per cent of water to make a plastic mass. When mixed with standard sand in the proportion of 1 : 3 it will need about 10 per cent of water, reckoned on the mixture, in order to make a plastic mass, *i.e.*, roughly double the amount used when it is neat. The mechanism of setting will be very different under these different conditions, but there is more than that. The aggregate, sand, stones, and the like, will be machanically in the way of progressive hydration; that, however, is a trifle compared with the thermal effect. The setting of cement generates heat, which in large masses and with quick-setting cements may cause a considerable rise in temperature. Indeed, the method of measuring rise of temperature has been suggested as a mode of determining the setting time—chiefly in Germany. Anything more lunatic is difficult to conceive. Where the cement is slow setting and the proportion of aggregate is considerable, say 6 or 8 to 1, as it generally is, the rise of temperature is not large unless the cement is so unsound that it contains what is conveniently termed "free lime." That idea may be dismissed with regard to cement made under modern conditions. What is of more moment is the influence of temperature on the rate of setting of cement. If the temperature is high the rate of setting is correspondingly high and may be too high for satisfactory construction.

Cements used in Madras at a tropical temperature and in winter in Canada, obviously are being employed under very different conditions, and it is the business of the cement manufacturer to provide a suitable material which shall act not as it does in a temperate climate, but in the place and under the conditions of actual use; he must be a little proleptic. I admit that the task is a hard one; proleptical tasks mostly are, but that the difficulties can be overcome is shown pretty clearly by results. When not only ordinary concrete but ferro-concrete has to be considered, the difficulties with regard to setting increase rapidly.

A 30-ton block may be made for harbour work and allowed to lie in the yard for six months, and if it does not set hard at once no one is much the worse, provided that the cement and aggregate are of good quality.

With ferro-concrete the matter is different. A reasonable time must be allowed for such things as piles, as they are not put immediately to use and may lie in the yard, but the ordinary ferro-concrete structure is mono-

* A contribution to a General Discussion on "The Setting of Cements and Plasters," held by the Faraday Society, January 14, 1918.

ithic, and the engineer responsible for the structure must know the period necessary for proper setting.

To sum up this part of the question of setting of cement in general, it appears to me—to put extant knowledge in the shortest way—that little is known about the mechanism of setting, save in the case of plaster of Paris; that the most important cement, Portland cement, is tested for setting time neat and is never used neat, and that there is no quantitative relation between its setting time neat and its setting time in concrete. The conclusion naturally follows that much earnest and thoughtful work must be done before we can arrive at anything which can be accepted generally as proved, not by authority, or as it were of faith, but *proved*.

THE SETTING AND HARDENING OF PORTLAND CEMENT *

By G. A RANKIN (Creighton, U.S.A.).

In order to understand thoroughly the nature of the setting and hardening of Portland cement, it is essential that one first consider the reactions which result when each of the constituent compounds is finely powdered and mixed with water, and also the effect which the admixture of the various constituents has on the nature of these reactions. While there is still much to be learned as to the chemistry of these reactions, sufficient data on the hydration of the individual major constituents have been obtained to enable us to account for the gradual hardening and increase in strength of Portland cement and to indicate the relative value of the constituents as cementing materials.

A statement concerning this matter, based on data obtained at the Geophysical Laboratory in Washington and the Bureau of Standards in Pittsburgh, is contained in the following pages. In this, brief mention will first be made as to the constitution of Portland cement clinker, after which the hydration of the constituents will be discussed. In conclusion, a general statement concerning the setting and hardening of Portland cement will be presented.

Portland cement clinker is the result of chemical combination of the three oxides, lime, alumina, and silica; but besides these three—which are the essential components—two others, namely magnesia and ferric oxide, always occur to some extent in commercial cement. The average of a large number of chemical analyses of American-made Portland cement shows that more than 90 per cent of an average Portland cement consists of the three oxides, lime, alumina, silica; one would expect, therefore, that its properties are due mainly to the presence of the above three components, and the relatively small admixture of the other oxides exerts at most a wholly secondary influence. Indeed, it has been shown that good Portland cement can be made from the three pure oxide,s lime, alumina, silica, in the proper proportions.

In order to determine the nature and number of the compounds or constituents of Portland cement clinker made from the pure oxides, lime, alumina, and silica, a careful study of all possible mixtures of these three oxides when fused was carried on at the Geophysical Laboratory. As a result of this study it was found that if such a pure Portland cement is perfectly burned it is made up of three constituents, namely, dicalcic silicate, tricalcic silicate, and tricalcic aluminate. If the clinker is not perfectly burned, that is, if the chemical reactions are not carried to completion, due to insufficient time or failure to attain a sufficiently high temperature, then two constituents other than the three already mentioned will be present. These two constituents are free lime and the compound $5CaO.3Al_2O_3$.

Without giving in detail the nature of the chemical reactions which result in the formation of the constituents of Portland cement clinker, it may be well to state that of the silicates, dicalcic silicate is the first formed; subsequently this compound unites with more lime in the formation of tricalcic silicate. This reaction takes place with great difficulty, due to the high temperature and length of time required. It is essential, however, that this reaction be carried practically to completion for the production of good cement, since the resulting compound tricalcic silicate is *the* essential constituent of Portland cement. Of the aluminates the compound $5CaO.3Al_2O_3$ is first formed. This compound subsequently unites with lime in the formation of tricalcic aluminate. While it is desirable that this reaction go to completion, it is not necessary for the production of a sound cement. However, the formation of the tricalcic aluminate takes place with such readiness that the reaction between lime and the compound $5CaO.3Al_2O_3$ is generally completed before the formation of the tricalcic silicate begins.

The major constituents of Portland cement clinker made up only of the oxides lime, alumina, and silica, are, therefore, the three compounds dicalcic silicate, tricalcic silicate, and tricalcic aluminate. The compound $5CaO.3Al_2O_3$ and free lime are minor constituents. Each of these compounds has optical properties peculiar to itself which serve to distinguish it from the rest. The several characteristic optical and crystallographical properties were obtained by a study of each compound by itself. These values are constants for the individual compounds in all mixtures made up from pure lime, alumina, and silica; *i.e.*, the final products resulting when such mixtures are heated are present as individuals of constant optical properties and not as solid solutions.

Microscopical examination of commercial Portland cement clinker shows it to be made up largely (over 90 per cent) of the three compounds tricalcic silicate, dicalcic silicate, and tricalcic aluminate. Free lime and the compound $5CaO.3Al_2O_3$ are occasionally present in small percentages. As for the effect of the presence of magnesia and ferric oxide, small quantities of which are always present in commercial clinker, it would appear from the available data that the magnesia is taken up in solid solution by the dicalcic silicate; while ferric oxide is present partly uncombined, in part it unites with lime to form $2CaO.Fe_2O_3$, and it also is taken up in solid solution by dicalcic silicate and the compound $5CaO\ 3Al_2O_3$ to an extent sufficient to colour these compounds.

Having thus briefly discussed the constitution of Portland cement clinker, let us now consider the hydration of the constituents in the following order: Lime, $5CaO.3Al_2O_3$, tricalcic aluminate, dicalcic silicate, tricalcic silicate.

Hydration of Lime.—The action of water on lime varies somewhat, depending on the temperature at which the lime has been burned. Ordinarily an amorphous hydrated material is first formed, which subsequently crystallises to lime hydrate. When lime occurs in a free state in Portland cement it is high burned, which, if not slowly hydrated by ageing or otherwise, will cause disintegration as the cement hardens. If the percentage of free lime in cement is relatively high, the action of water is very violent, at times being of an explosive nature.

Hydration of the Compound $5CaO.3Al_2O_3$.—When this compound is mixed without 30 per cent of water it sets and hardens very rapidly. When moulded specimens are placed in either hot or cold water, however, they disintegrate with great readiness. This is partly due to dissociation, which takes place readily when an excessive percentage of water is present, and partly to the solubility of the $5CaO.3Al_2O_3$. Microscopical examination of this compound when mixed with a large amount of water shows the rapid formation of an amorphous material about each individual grain. At times this amorphous material will in part crystallise. The available data would tend to show that the crystals thus formed are a hydrate of tricalcic aluminate.

* A contribution to a General Discussion on "The Setting of Cements and Plasters," held before the Faraday Society, January 14, 1918.

Hydration of the Compound Tricalcic Aluminate.—When tricalcic aluminate is mixed with water it sets and hardens rapidly, and while moulded specimens when placed in water remain sound, they develop but little strength, are rather soft, and comparatively soluble in water.

Microscopical examination of this compound when hydrated shows the formation of an amorphous material which at times will completely crystallise. This would tend to prove the crystalline material is a hydrate of tricalcium aluminate.

The Hydration of Dicalcic Silicate.—When dicalcic silicate is mixed with water the action is exceedingly slow, and it is only after a long period of time, a matter of several months, that a moulded specimen when placed in water will develop any considerable strength. The specimen remains sound, however, and is not readily soluble.

Microscopical examination of dicalcic silicate which has been shaken for a considerable time with an excess of water shows the formation of a coating of amorphous material on the individual grains. It would not appear that this action results in the formation of any hydrated calcium silicate. The amorphous material shows no tendency to crystallise, except that lime which leaches out forms a crystalline hydrate of lime. This leaching out of the lime from the amorphous hydrated dicalcic silicate is apparently a process which will continue until amorphous silica alone remains, if a sufficient quantity of water is present for the solution of the lime.

When mixed with the other constituents of Portland cement clinker and shaken with water, the hydration of dicalcic silicate is not affected except in the case of tricalcic aluminate, when the rate of formation of amorphous material on the grains of dicalcic silicate is materially increased. This is undoubtedly due to the fact that dicalcic silicate is more readily soluble in a solution saturated with the aluminate, which is itself so readily soluble in water.

Hydration of Tricalcic Silicate.—When this compound is mixed with water it sets and hardens rather rapidly. Moulded specimens when placed in water remain sound, and within a reasonable time develop a strength comparable to that of the best of Portland cements.

Microscopical examination of hydrated tricalcic silicate shows that an amorphous material is formed similar to hydrated dicalcic silicate. The rate at which this amorphous material is formed in the case of tricalcic silicate is, however, much greater, as is also the rate at which lime can be leached from amorphous tricalcic silicate than is the case with amorphous dicalcic silicate. In either case it does not appear that any definite hydrated calcic silicate is formed, since it is possible to leach or dissolve out the lime, leaving amorphous silica behind from the amorphous material formed from both silicates.

When tricalcic silicate is mixed with the various other constituents of cements in water, it does not appear that the rate of formation of amorphous tricalcic silicate is affected.

From this description of the action of water on the constituents of Portland cement, it will be seen that the setting and hardening of Portland cement involve the formation of an amorphous hydrated material which subsequently partially crystallises; that the initial set is probably due to the hydration of tricalcic aluminate; that the hardness and cohesive strength at first are due to the cementing action of the amorphous material produced by the aluminate and of tricalcic silicate; and that the gradual increase in strength is due to further hydration of these two compounds, together with the hydration of dicalcic silicate.

Of the three compounds which thus take part in the setting and hardening of Portland cement, the tricalcic silicate appears the best cementing constituent; that is, this compound is the only one of the three which when mixed with water will set and harden within a reasonable time to form a mass which in hardness and strength is comparable to Portland cement. The compound dicalcic silicate requires too long a time to set and harden in order to be in itself a valuable cementing material. The compound tricalcic aluminate, while it sets and hardens rapidly, is rather soluble in water and is not particularly durable or strong.

From this it would appear that the compound tricalcic silicate is *the* essential constituent of Portland cement. In other words, it is tricalcic silicate which imparts to Portland cement its valuable cementing properties.

In this connection it is interesting to compare the nature of the setting and hardening of tricalcic silicate with an ideal cement which M. Vicat worked out theoretically about one hundred years ago.

M. Vicat, who carried on a very interesting series of experiments in regard to the hardening of cements and plasters, seemed to believe that the lime in cement mortar should be in a state of chemical combination, and that it were best that it should be so combined with gelatinous silica.

When tricalcic silicate is mixed with water to form a mortar, a gelatinous material is formed which is composed of hydrous lime and silica. Whether the lime and silica continue to be chemically combined, or whether the gelatinous material is colloidal, is still a matter of some uncertainty, although it would appear that this material is colloidal.

The similarity between Vicat's theoretical cement and tricalcic silicate is thus apparent.

The basis for Vicat's theoretical reasoning was undoubtedly derived from his observations on the action of hydrated lime when ground with water and pozzolana, a material which contains over 40 per cent silica, with smaller percentages of alumina, magnesia, ferric oxide, and alkalis. This mixture, commonly known as Roman cement mortar, it would now appear, sets and hardens in much the same manner as tricalcic silicate; in the case of Roman cement the formation of the gelatinous material, which subsequently hardens, being due to the action of lime water on the pozzolana. This action, however, is exceedingly slow, and it requires a much longer time for the completion of the hardening in Roman cement mortar than in mortar containing tricalcic silicate. This is undoubtedly due to the nature of the chemical combinations of silica in pozzolana, which react with water much less readily to form gelatinous silica than is the case of the silica combined in tricalcic silicate. This circumstance, that gelatinous silicate is released with such readiness when tricalcic silicate is mixed with water, is probably the reason why this compound is such a valuable cementing material. Without discussing at length the nature of the cementing value of gelatinous silica, it may be well to state that it seems probable that certain of the toughest sandstones (ideal concrete structures) are made up of grains of sand originally cemented together with gelatinous silica which was gradually deposited from solution on to the grains of sand and subsequently hardened.

This foregoing discussion, which tends to prove that gelatinous silica is the most essential constituent of a cement mortar, is somewhat speculative. Even so, such speculation is desirable, due to the fact that by formulating advance theories as to the probable outcome of an investigation one may sooner attain the end.

Let us now consider certain possibilities which might increase the percentage of gelatinous silica in cement mortars. We know at the start in such an investigation that tricalcic silicate is probably the only compound containing silica in combination in such a manner that it is *readily* released to form a thin coating of gelatinous silica when mixed with water to form a mortar. Therefore, until some other compound is discovered in which the silica is combined in such a way that it is more readily available in the gelatinous state, the best way to increase its percentage in cement mortars is to increase the percentage of tricalcic silicate in cement clinker. At the present time an average Portland cement contains about 30 to 35 per cent of this compound. To increase this percentage is a matter of considerable difficulty.

Pure tricalcic silicate is formed by combination of lime and silica at a temperature of 1700° C., which is too high for industrial practice. In order that this compound form readily and at a sufficiently low temperature to become a commercial possibility, it is essential that some low-melting flux be present to facilitate the combination of lime and silica to form tricalcic silicate. At present this this flux is to a large extent furnished by the low-melting calcium illuminates and the small amount of iron oxide and magnesia present in the clinker.

Cements have been made in which the ferric oxide or magnesia has been increased in percentage up to 7 or 8, and while there has been no notable increase in the percentage of tricalcic silicate, these cements are sound and of good strength. The iron cement in particular has been found very useful, since it resists the action of sea water much better than ordinary Portland cement. The reason for this is undoubtedly due to the formation of some chemical combination of the iron oxide with the calcium aluminates which resists the soluble and disintegrating action of sea water. While the nature of this chemical combination is uncertain, it is known that the pure aluminates, particularly the compound $5CaO.3Al_2O_3$ when burned with about 5 per cent of iron oxide, produce a clinker which when ground and mixed with water is sound and of good strength. A pat of this material, even when subjected to the action of steam for a long period of time, shows no sign of disintegrating.

To return to a consideration of the possibility of producing a cement containing a higher percentage of readily hydrated silica than Portland cement now does, it would not appear that it is commercially possible to increase the percentage of tricalcic silicate in order to attain this end. There is, however, at least one other possibility, which may be more practical. This involves the attempt to readily release hydrous silica from some compound containing a higher percentage of silica than the compound tricalcic silicate. This seems not unreasonable, since it will be remembered that dicalcic silicate, while it is practically inactive towards pure water, is quite appreciably hydrated in a solution of the calcium aluminates. It may be that some other solution or electrolyte will be found which will release hydrated silica from this compound as readily as water now releases it from tricalcic silicate.

In conclusion, let us recapitulate the main points contained in this paper. The value of Portland cement depends upon the fact that when finely powdered and mixed with water an amorphous gelatinous-like material is formed on the individual grains cementing them together. This amorphous material results from the major constituents, tricalcic silicate, dicalcic silicate, and tricalcic aluminate. Of these constituents, the compound tricalcic silicate is the one which hardens and develops the greatest strength within a reasonable time. This is due to the gelatinous hydrated silica which is readily released when this compound, in a finely powdered state, is mixed with water. This most important constituent, which is the one which formed with the greatest difficulty, makes up about 30 to 35 per cent of an average normal Portland cement. It may be said, therefore, that the essential process for the manufacture of Portland cement is the formation of this compound, and that any improvement in this process yielding an increased percentage of tricalcic silicate will increase the cementing value of Portland cement. The increase of the percentage of the tricalcic silicate does not appear economically or practically possible, however, at the present time. A more feasible plan of attack for improving the durability of cements would appear to be an attempt to release hydrous silica from some compound such as dicalcic silicate, which contains a higher percentage of silica than tricalcic silicate, by the dissolving action of some suitable electrolyte. Investigation along these lines may ultimately result in the discovery of a cement which will enable us to prepare a concrete closely approaching the ideal: grains of sand cemented together with hydrous silicate—the toughest of sandstones.

THE VISCOSITY OF BLAST-FURNACE SLAG AND ITS RELATION TO IRON METALLURGY, INCLUDING A DESCRIPTION OF A NEW METHOD OF MEASURING SLAG VISCOSITY AT HIGH TEMPERATURES.*

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(Continued from p. 41).

The Temperature-viscosity Relations of Graded Series of Synthetic Slags.

The only satisfactory method of studying the temperature-viscosity relations of blast-furnace slags and the effect of the different constituents on the viscosity is the determination of such relations for a graded series of synthetic slags in which one constituent is gradually replaced by another.

Investigations of this kind are now in progress in these laboratories. The results of this work are to be published as a Bureau of Mines Technical Paper.

To illustrate the experimental results which are being obtained, there is shown in Fig. 1 (*prox.*) the temperature-viscosity relations of a synthetic slag containing 48 per cent lime (curve A), and of a synthetic slag of the same composition except that 20 per cent of the lime has been replaced by an equal percentage by weight of magnesia (curve B).

The Literature on Slag Viscosity.

The viscosity of blast-furnace slag had not been measured previous to the investigation described in this report. A number of investigators have determined the "fusibility," or softening temperature, of slags by means of the cone method or other deformation method, but these methods supply only limited information regarding the temperature-viscosity relations of the slag in question. Any deformation method that may be employed indicates only the temperature at which the slag attains a more or less definite viscosity, the magnitude of the value obtained depending on the method used. The cone method was first carefully applied to the study of slags by Boudouard (55).

Fulton (56) has determined the melting-points of a series of copper slags by means of the thermal method of the Geophysical Laboratory. Such melting-points correspond to that temperature at which the slag passes entirely from the crystalline to the amorphous state, and have no direct relation with the viscosity of the melt. Fulton obtained an idea of the temperature at which the slag became fluid by stirring the melt with a heavy platinum rod. The melting-point temperature was much lower than the "fluidity" temperature, the difference between these two temperatures being extremely variable. An apparatus, consisting essentially of a graphite crucible with an elongated orifice in the base has been devised by Johnson (57) for determining the "dripping"-point of slags. This device has also been used by Guess and Lathe (58).

The customary methods of viscosity measurement have been very slowly applied to measurements at high temperatures, owing to experimental difficulties. In 1917 Lorenz and Kalmus (59), and Goodwin and Mailey (60) measured the viscosity of a number of molten salts of the alkali metals, lead and silver, by means of the capillary flow method up to temperatures of 500—600° C. Greiner (61), working with a modified Tammann apparatus, measured during this same year the viscosity of sodium and potassium silicates, and of mixtures of these silicates with alumina, magnesia, lime, and ferrous oxide, up to temperatures as high as 1200° C. Measurements, however, were referred to the viscosity of fused sodium ortho-silicate as a standard of comparison, and hence the absolute magnitude of his

* A Paper communicated to the *Transactions of the Faraday Society*. Published by permission of the Director, U.S. Bureau of Mines.

observations is not known. In 1908 Fawsitt (62) employed the method of Coulomb (63) to determine the viscosity of mercury up to 216° C., and of sodium nitrate up to 450° C. In the same year Arndt (64) measured the viscosity of boric anhydride, sodium metaphosphate, and mixtures of the two at temperatures at 700—1100° C., by observing the time of fall of a platinum cylinder within the molten substance. Such a method is suitable for extremely viscous liquids only, and could be applied with difficulty to blast-furnace slags at working temperatures. Arndt also measured the viscosity of glass by this method at temperatures at 1050–1130° C. Doelter (65) in 1913 applied the method of Arndt to the determination of the viscosity of a synthetic diopside containing 5·02 per cent of ferrous oxide. A large temperature coefficient of viscosity was noted, the viscosity at 1300° C. being five times that of castor oil. This isolated measurement by Doelter on a single mixture represents the highest temperature reached in the various viscosity investigations previous to those described in this report, in which results have been referred to absolute units. Arbitrary deformation tests have, of course, been made at much higher temperatures.

Theory of the Method Employed.

In these investigations the author has used a modification of the method originated by Margules (66) in 1881. In this method the liquid is confined between two concentric cylinders. The outer cylinder is rotated at a constant speed, and the torque exerted upon the inner cylinder is measured. The method is applicable to liquids of a wide range of viscosity, and has been used with modifications by Gurney (67) in the accurate measurement of the viscosity of water. The principle of the method is used in the Stormer and Clark viscosimeters, which find application in the physical testing of petroleum, oils, lubricants, and clay slips, although the existence of a friction couple for which correction cannot be well made renders this type of apparatus relatively inaccurate. Recent types of viscosimeters, such as those of Carmichael and Grosvenor (68) and of Kottmann (69), which are designed for purposes similar to those of the Stormer apparatus, adhere more closely to the original idea of Margules in that the error due to friction is absent. In 1913 Hatschek (70) used the method for determining the viscosity of emulsions, emulsoids, and sols, and secured some extremely interesting experimental results.

The principle of the method employed by the author is therefore not a new one. The torsion method, however, had not hitherto been employed at all for measurements of viscosity at temperatures higher than are generally used in testing oils, &c.; *i.e.*, about 250° C. Quite paradoxically it appears to be the only method of measurement which is possible experimentally over a wide range of temperature and of viscosity, and for this reason may be called a quite universal method. In applying the method to temperatures as high as 1600° C., which is about 400° C. higher than the property of viscosity had been hitherto measured by means of any method, certain modifications in the construction of the apparatus were necessary, which alone made possible the attainment of a relatively great accuracy under the rather severe experimental conditions. These modifications consisted in the use of Acheson graphite in the construction of all parts of the apparatus subjected to high temperatures, and in the use of a system of damping the suspended system so as to give to it the stability and aperiodicity characteristic of the familiar damped D'Arsonval galvanometer. It is the opinion of the author that the use of this method of damping in the case of the recent type of viscosimeter described by Carmichael and Grosvenor would make i applicable to measurements on much more viscous liquids than is possible without such an addition to the apparatus.

The present modification of the method of Margules has been applied without difficulty to measurements on slags over a range of viscosity from 200 to 3000 (H_2O at 20° C. = 1). It is certain, however, that the method is applicable over a much wider range of viscosity than this (71).

Experimental data derived by means of the torsion method are capable of an easy direct mathematical interpretation, in which respect it has a great advantage over other methods such as that of Segel (72), in which the fall of a metal rod within a hollow cylinder, is measured, the space between being filled with the viscous substance. The method of Arndt approaches more closely the conditions imposed by the use of Stokes's law governing the fall of a sphere in a viscous medium; but even here the interpretation of results is dependent on an assumption, which, however, is probably entirely permissible under the given experimental conditions.

In the torsion method the outer cylinder is rotated about a vertical axis at a constant speed. The inner cylinder is suspended coaxially within the outer one by means of a steel or phosphor-bronze ribbon. The space between them is filled with the liquid, whose coefficient of viscosity may be designated as η. In may be shown (73) by means of the equation of Navier and the equation of continuity that a cylinder of radius b, rotating with a constant angular velocity, ω, will exert upon an inner fixed concentric cylinder of radius a (the space between them being filled with the liquid), a couple Γ, given by the relation—

$$\Gamma = 4\pi\eta L \frac{a^2b^2}{b^2 - a^2}\,\omega,$$

where L is the common length of the two cylinders and the effect due to the ends is disregarded, and a and b are the radii of the inner and outer cylinders respectively. It is at once evident that with cylinders of fixed dimensions the velocity is proportional to the torsion couple Γ and inversely proportional to the speed of rotation in revolutions per second. Conversely, the torsion couple is proportional to the speed of rotation and also proportional to the viscosity. In the present experiments the observed end effect, or torsion couple arising from the shear exerted by the end surfaces, amounted to 23 per cent of the total effect. This end effect was determined by the use of two inner cylinders of equal diameter but of different lengths (5·08 and 2·70 centimetres). An appreciable fraction of the end effect was obviously caused by the immersed part of the cylindrical shaft supporting the inner cylinder. On account of the experimental conditions at high temperatures it was not possible to use a supporting shaft of very small diameter, such as is easily possible at lower temperatures. As is shown later, the torsion couple, inclusive of the end effect, is proportional to the speed of rotation and also to the viscosity of the liquid over a considerable range of speed and viscosity; so that the error arising from the end effect was probably within other known experimental errors. Hence it was not necessary to apply any correction for variations of end effect for different viscosities of the liquid slag.

The theoretical conditions are, among other things, that the cylinders are concentric, and that the conditions about the ends—that is, the depth of slag and relative position of surfaces—is the same in every case. Couette (74) in early experiments with this method has shown that in this case, as in others where the magnitude of a physical effect depends on the relative position of nearly concentric cylinders, a slight eccentricity produces an error relatively much smaller. Gurney (75) found that in the case of measurements with water as the liquid and with an inner cylinder of 4·5 cm. radius, a displacement of 1 mm. from the central axis of the outer cylinder caused an error which was inappreciable. He remarks:—Any departure from a truly circular cross section in the cylinders, or any tilting or lack of concentricity would cause an apparent increase in η, since the ideal case is the case of minimum deflection. The actual case may also differ slightly from the ideal in other ways, and the tendency would usually be to increase the apparent value of η." In the experi

ments described herein it is probable that the eccentricity of the inner cylinder did not exceed 1 mm., although an eccentricity of this magnitude was sometimes noted, without any appreciable effect on the observed deflection.

Probable Effect of Surface Slip.—Twenty-three years after the pioneer work of Poiseuille (1842), in establishing the laws of internal friction in fluids, Helmholtz and Piotrowski (76) concluded from certain experiments, in which a sphere full of a liquid was allowed to oscillate, that there existed at least in some cases a "slip" at the boundary plane between solid and liquid. Whetham (77), however, twenty-five years later, obtained convincing evidence from experiments with a silvered capillary that there was no "slip" for such liquids as were used by Helmholtz and Piotrowski. He attributed their results to an insufficient recognition of the effects of temperature and to an inconstancy in the bifilar suspension used. Whetham's conclusions have found substantial support from the later researches of Mutzel (78), 1891, Drew (79), 1901, Arnold (80), 1911, and Zemplen and Pogany (81), 1916. In general, it seems that the more sensitive the experimental method the smaller the possible value of the "slip" coefficient becomes.

Margules (82) has derived an expression for the torsion couple exerted upon the inner cylinder which takes into account the existence of a surface "slip." It is—

$$\Gamma = 4\pi\eta L \frac{\omega}{2\gamma\left(\frac{1}{a^3} + \frac{1}{b^3}\right) + \left(\frac{1}{a^2} - \frac{1}{b^2}\right)}$$

where γ is the "slip" coefficient or "Gleitungskoefficient." When γ is equal to zero, the expression reduces to that previously given—

$$\Gamma = 4\pi\eta L \frac{a^2 b^2}{b^2 - a^2} \omega$$

derived on the assumption that there is no slip between the solid and the liquid at the boundary plane.

In the present investigations the magnitude of the slip has not been determined, but has been assumed to be equal to zero in the case of the low rates of shear employed—about 1 revolution per second.

Notes.

55. O. Boudouard, "Experiments on the Fusibility of Blast-furnace Slags," *Journ. Iron and Steel Inst.*, 1905, lxvii., 339.
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(To be continued).

THE ORES OF COPPER, LEAD, GOLD, AND SILVER.

By CHARLES H. FULTON.

(Continued from p. 27).

Classification of Ores Proper.

The ore classification mentioned above follows.

Copper Ores (may contain gold and silver).—

1. *Ores Containing Metallic Copper.*—Example: Keweenaw Peninsula, Michigan. Native copper in altered amygdaloidal basic lava and interbedded conglomerates. The ores are concentrated and the metallic copper concentrate obtained is smelted.

2. *Ores Containing Iron and Copper Sulphides, and the minerals which are formed by their oxidation.*—Divisible into three sub-classes, as follows:—

(a) Massive iron sulphides, pyrite and pyrrhotite, and copper sulphides. Smelted direct. Examples: Ducktown, Tenn.; Shasta County, Cal.; Mount Lyell, Tas-

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* *Technical Paper* 143, Department of the Interior, U.S.A. Bureau of Mines.

mania; Yak mines; Leadville, Colo.; Rio Tinto, Spain; Sudbury, Canada.

(b) Copper and iron sulphide minerals, or the oxidised minerals derived from them, intermixed with a large amount of gangue minerals. Usually in normal fissure veins or in impregnations. Smelted direct, or concentrated and smelted. Oxidised ores may be treated by leaching. Examples: Butte, Mont.; Bingham, Utah; Bisbee, Ariz.

(c) Copper and iron sulphide minerals or oxidised copper minerals, disseminated in small grains throughout eruptive or metamorphic rocks (so called porphyry ores). Concentrated and smelted. Oxidised ores may be subjected to a leaching process. Examples: Bingham, Utah; Ely, Nev.; Santa Rita, N. Mex.; near Globe, Ariz.

Ores Containing Lead and Copper.—

Lead and copper minerals, usually some zinc blende and iron sulphide with the gangue minerals, in fissure veins or in impregnations. Frequently contain considerable gold and silver. Concentrated and smelted, or smelted direct. Examples: Silverton, Colo.; Park City, Utah; Georgetown, Colo.

Lead Ores (may contain zinc minerals).—

1. *Ores Commercially free from Precious Metal.*—Lead as galena, usually disseminated throughout limestone. Oxidised lead minerals subordinate. Concentrated and smelted. Example: Southeastern, Missouri.

2. *Ores Containing Precious Metal.*—Two sub-classes, as follows:—

(a) Chiefly sulphides of iron and lead, or the oxidised minerals derived from them. Smelted direct. Example: Leadville, Colo.

(b) Galena, and other sulphides, with gangue minerals in fissure veins or in impregnated deposits. Smelted direct or concentrated and smelted. Examples: Cœur d'Alene, Idaho; Aspen, Colo.

Ores Containing Lead and Zinc.—

1. *Ores Commercially free from Precious Metals.*—Galena and sphalerite, in large bodies or disseminated in grains through limestone. Concentrated and separated into lead and zinc products, each product smelted separately. Example: Joplin district, Mo.

2. *Ores Containing Precious Metals.*—Galena and sphalerite, and minerals derived by their oxidation; either in veins or similar impregnated deposits or as large masses. Smelted direct or concentrated and separated into lead and zinc products that are smelted separately. Example: Broken Hill, Australia; Creede, Colo.; Park City, Utah.

Gold Ores (contain silver, but its value is subordinate to that of the gold).—

1. *Ores Containing "Free" Gold and Gold closely Associated with Sulphides.*—Divisible into three sub-classes, as follows:—

(a) Gold content largely "free" and recoverable by amalgamation. Gangue chiefly quartz, or siliceous rocks; iron sulphides or sulpho-arsenides present not exceeding about 6 per cent of the ore by weight. Treated by amalgamation, followed by concentration or cyanidation, or both. Examples: Homestake, S. Dak.; Douglas Island, Alaska; Rand mines, South Africa; Grass Valley, Cal.

(b) Gold free in part, but chiefly associated closely with iron sulphide minerals. Sulphides, mainly those of iron, may be present in considerable amount. Gangue siliceous. Treated by amalgamation, cyanidation, or by a combination of these processes. Examples: Camp Bird mine, Ouray, Colo.; Morro Velhoe, Minas Geraes, Brazil.

2. *Ores Containing Gold in Chemical Combination* (gold in the tellurides, calaverite, and sylvanite).—Some free gold may be present. Gangue siliceous. Iron sulphides may be present in considerable amount. Other sulphides in smaller amounts. Treated by cyanidation, or concentration, or both. Examples: Cripple Creek, Colo.; Goldfield, Nev.; Kalgoorlie, Australia.

Gold-Silver Ores.—

Silver and gold both present in considerable amount. Silver and gold may be present in complex mineral form. Gangue, largely quartz or siliceous rocks. Treated by cyanidation or concentration or by both methods. Examples: Liberty Bell, San Juan district, Colorado; El Oro, Mexico.

Silver Ores.—

Main value in silver; a little gold always present.

(a) Silver in the form of native silver. Sulphides present in small amount. Gangue, calcite, quartz, or siliceous rocks. Treated by concentration, amalgamation, cyanidation, or all methods combined. Examples: Cobalt district, Canada; Batopilas, Mexico.

(b) Silver present mainly as argentite or as oxidised silver minerals; gangue, quartz, or siliceous rocks. Sulphides in small amount. Treated by cyanidation, or cyanidation combined with concentration. Examples: Palmarejo mines, Chihuahua, Mexico; Pachuca, Mexico.

(c) Silver present in complex silver minerals such as proustite, pyrargyrite, tetrahedrite, with some argentite and native silver. Other sulphides, as galena, stibnite, and pyrite, present in small quantities; gangue, limestone, quartz, or siliceous rocks. Treated by cyanidation and concentration combined, or by smelting. Examples: Parral, Mexico; Tonopah, Nev.; Guanajuato, Mexico; Aspen and Creede, Colo.

Descriptions of Classified Ore Types.

Following are more detailed descriptions of the ore types given in the classification:—

Ores Containing Metallic Copper.

Michigan.—The copper in the Michigan ores occurs crystallised in part, but chiefly as massive copper, forming casts and fillings in the conglomerates, replacing both the original pebbles (of felsitic porphyrite) and the matrix, and in the amygdaloid lavas (diabase), filling the amygdules or openings formerly occupied by entrapped gases. The ore or "copper rock" is crushed, and the copper concentrated into small bulk, the product being known locally as "mineral." This mineral contains on the average 60 to 75 per cent copper, with an admixture of some of the heavier gangue silicate minerals of the ore, and is smelted and refined into pure copper. The copper contents of the ores as mined range from 0·75 to 1·50 per cent, or from 14 to 30 pounds of copper per ton. In 1914 the copper produced from these ores amounted to 158,009,748 pounds—about 10·1 per cent of the United States production.

Massive Iron Sulphides and Copper Sulphides.

Ducktown, Tenn.—The Ducktown ore occurs in lens-shaped bodies in schists, and consists essentially of pyrrhotite and pyrite, which constitute 60 to 75 per cent of the ore. Calcite, quartz, actinolite, tremolite, zoisite, pyroxene, garnet, felspar, and chlorite are gangue minerals. Small amounts of chalcopyrite, zinc blende, and bornite are present. The copper content of the ore averages about 1·95 per cent. A typical chemical analysis is as follows:—Copper, 1·97 per cent; sulphur, 23·7 per cent; silica, 21·9 per cent; iron, 32·6 per cent; alumina, 3·6 per cent; lime, 5·8 per cent; magnesia, 1·9 per cent.

The copper is recovered by pyritic smelting. In this process the mineral condition of the iron and silica is important, and one of the difficulties of metallurgical treatment in the district arises from the fact that a large part of the silica in the ores is already combined in silicate minerals. This district produced in 1914 18,661,112 pounds of copper, or 1·19 per cent of the United States production.

Shasta County, Cal.—The ore of the Mammoth and Iron Mountain mines are chiefly massive pyrite, with some chalcopyrite, a little bornite and sphalerite, and some quartz. The ores have the following analysis:—Copper, 4·06 per cent; silica, 12·4 per cent; iron, 35·4 per cent; zinc, 4·2 per cent; sulphur, 42·7 per cent; alumina, 3·8 per cent; lead, 0·087 per cent; gold, 0·032 ounce per ton; silver, 2·26 ounces per ton.

Other ores in the district are similar, but contain somewhat smaller amounts of pyrite, less copper, more sphalerite, and more silicate minerals. The analysis of Balaklala ore is as follows:—Copper, 2·7 per cent; silica, 25·8 per cent; iron, 30·3 per cent; alumina, 4·1 per cent; sulphur, 37·5 per cent; gold and silver, 90 cents per ton. Bully Hill ore contains considerably more sphalerite and chalcocite, as well as chalcopyrite, some barite, and silicates of alumina, and more gold and silver. An average analysis shows 20 per cent sulphur, 23 per cent silica, and 4 per cent copper.

The ores of the district are treated chiefly by pyritic smelting, siliceous ore for the smelting mixture being obtained from local sources, from Idaho, and from Goldfield and Tonopah, Nev.

Mount Lyell, Tasmania.—The Tasmanian ores are of two types, Mount Lyell and North Mount Lyell, which are mixed in such proportion as to make a suitable furnace mixture.

Mount Lyell ore consists in the main of crystalline cupriferous pyrite, small amounts of tetrahedrite and chalcopyrite, a little sphalerite, mixed with a small amount of quartz and barite. The copper content varies, ranging from 4·5 per cent down to 0·75 per cent. A typical average analysis is—Iron, 42·02 per cent; silica, 2·12 per cent; alumina, 1·87 per cent; lead, 0·65 per cent; zinc, 1·30 per cent; sulphur, 48·77 per cent; arsenic, 0·30 per cent; copper, 0·73 per cent; about 2·5 ounces of silver and 0·08 ounce of gold per ton.

North Mount Lyell ore has quartzite and slate as gangue rocks, through which are disseminated the copper minerals, chiefly bornite and some chalcocite and chalcopyrite, and small amounts of pyrite. A typical average analysis is—Silica, 66·6 per cent; iron, 6·80 per cent; alumina, 7·50 per cent; copper, 6·47 per cent; silver, 1·80 ounces per ton; and gold, 0·01 ounce per ton.

Leadville, Colo.—The ores from the Yak mines, Leadville, consist chiefly of crystalline granular cupriferous pyrite, mixed with an appreciable amount of spalerite, small amounts of chalcopyrite, galena, quartz, calcite, and kaolin. The average composition of the ores is as follows:—Iron, 33 to 44 per cent; sulphur, 38 to 45 per cent; alumina and silica, 4 to 20 per cent; zinc, 4 to 8 per cent; copper, 0·5 to 3·5 per cent; lead, up to 0·5 per cent; silver, 2 to 8 ounces per ton. The Yak ores are mixed in proper proportion with highly siliceous ores, which usually contain precious metal, and are smelted by pyritic smelting or are roasted and used for their iron content as flux in lead smelting.

Rio Tinto, Spain (H. F. Collins, "Pyrites Deposit of Huelva," *Mining Mag.*, 1911, v., 121).—The ore bodies are segregated masses of sulphides in slates and schists associated with eruptive rocks. The ores consist essentially of cupriferous pyrite, the copper occurring mainly as chalcopyrite, chalcocite, and covellite. The amount of gangue minerals, such as quartz, calcite, and dolomite is very small. The sulphur content of the ore is 45 to 48 per cent, pure pyrite containing 53·3 per cent sulphur. The copper and the sulphur contents of the ore vary, the average copper content being about 2·5 per cent. Ores below 2 per cent copper are sold for the manufacture of sulphuric acid. The copper from the higher grade ores is extracted by both leaching and smelting methods.

Sudbury, Canada.—The ores consist chiefly of pyrrhotite, through which is disseminated varying amounts of pentlandite (NiFe)S, a nickel-iron sulphide, and a considerable amount of chalcopyrite. Some pyrite is also present. The gangue consists in the main of the inclosing rocks of the ore body, norite, and of chlorite schist, and in places of quartzite. An average analysis of the ores is—Silica, 10·10 per cent; iron, 44·68 per cent; alumina, 6·85 per cent; lime, 1·19 per cent; magnesia, 1·14 per cent; sulphur, 27·48 per cent; copper, 1·77 per cent; nickel, 5·62 per cent.

The ores are first roasted to expel sulphur and to oxidise the larger part of the iron, and then smelted in the blast furnace and in the reverberatory furnace. Pyritic smelting has been tried with these ores, but has not succeeded, owing probably to the fact that the silica in the gangue is nearly all combined in silicates.

(To be continued).

PROCEEDINGS OF SOCIETIES.

SOCIETY OF GLASS TECHNOLOGY.

Ordinary Meeting, January 16, 1918.

Mr. Williams Thomas in the Chair.

The following papers were read:—

"*The Durability of Heavy Lead Potash Glass.*" By J. D. Cauwood, M.Sc., W. E. S. Turner, D.Sc., and Duncan Webb.

Prior to 1870 large quantities of lead glasses were used for chemical ware. Nowadays lead in chemical ware is practically non-existent, only one glass out of many used for this purpose gave signs of containing lead on analysis. The authors have carried out durability tests on certain glasses containing a high percentage of lead to find how far they were resistant to the action of solvents. A summary of the results of workers in the past was given, and it was found by most of these workers that lead glasses were highly resistant to water and acids and fairly resistant to the action of alkalis.

The two glasses tested were supplied by Mr. Duncan Webb. One, a window glass made in 1845, and which, although it had been exposed to weathering conditions for more than fifty years showed no diminution in brilliancy, had the following analysis:—

	Per cent.
SiO_2	47·1
PbO	41·2
K_2O	8·3
Al_2O_3	0·6
CaO	1·3
B_2O_3	1·2

The other glass was a tumbler made in the early fifties, and which also had lost none of its brilliancy. It had the following percentage composition:—

SiO_2	54·7
PbO	28·0
K_2O	16·7
Al_2O_3	0·6
CaO	Trace

Five tests in all were applied, namely (1) Boiling hydrochloric acid, (2) 2/N sodium carbonate, (3) 2/N caustic soda, (4) boiling water, (5) water under pressure (autoclave). The results obtained were as follows:—

1. *Boiling Acid.*—The two lead glasses were superior to any of the modern chemical ware glasses, being far superior to Jena.

2. *Sodium Carbonate.*—The lead glasses were slightly inferior to the best modern chemical ware.

3. *Caustic Soda.*—The lead glasses showed slight inferiority.

4. *Autoclave Test.*—The window glass was superior and the tumbler inferior to modern chemical ware.

5. *Boiling Water.*—Both lead glasses were equal in behaviour to the chemical ware.

In each case actual results were quoted.

It is obvious from these results that lead glasses are quite satisfactory from the point of view of both weathering and the attack of reagents.

"*Notes on the Annealing of Glass.*" By S. English, M.Sc., and W. E. S. Turner, D.Sc.

Investigations had been carried out on two particular

glasses by a special method which was described, and it was found that 620° C. was the temperature at which the strain rapidly disappeared from one glass, 460° C. for the other. Lantern slides illustrative of the method used were shown as well as curves showing results. The effect of temperature on annealing was also investigated. Thus in the case of one glass, annealing was completed in six and a half hours at 400° C., in two and a half hours at 425° C., and in twelve minutes at 450° C.

As the method outlined was a laboratory one involving expensive apparatus, a more simple method involving the measurement of bending of rods of glass has been worked out. It was found that the temperature at which a glass showed rapid bending without actual softening corresponded to the actual annealing temperature. The method could be applied, and in fact had been introduced into works practice. When a particular type of glass was placed in the lear a road was made from it and also placed in the lear, resting on a brick. This rod was about 4 feet long and 7 mm. diameter. When the bending at the ends was only half an inch the annealing was unsatisfactory and the ware "fled;" if the rod bent until it touched the floor of the lear the annealing was again unsatisfactory, as all the wear was "melted." Satisfactory annealing was attained by a bending at the ends of about one inch.

Various types of cooling curves were discussed, and it was shown that the best cooling curve in a lear was a sinuous curve.

"*An Account of a New Blowpipe with Pre-heated Gas.*" By W. A. WHATMOUGH, B.Sc., A.I.C.

The actual working of the instrument was shown, and its construction explained.

"*A New Variable Jet Blowpipe.*" By S. ENGLISH, M.Sc.

As in the previous paper the instrument was shown in actual use.

Prior to the meeting visits were made by parties of members to the works of—(1) Messrs. Stevens and Williams, Brierley Hill; (2) Messrs. Thomas Webb, Ltd., Stourbridge; (3) Messrs. Webb and Corbett, Ltd., Stourbridge.

The thanks of the Society are due to these firms for their kindness, which was highly appreciated by the visitors.

The next meeting of the Society will be held at Sheffield on Wednesday, February 20, 1918.

NOTICES OF BOOKS.

Principles of Quantitative Analysis. By WALTER C. BLASDALE, Ph.D. Second Edition, Revised and Enlarged. London: Constable and Co., Ltd. 1917. Pp. xii+402. Price 10s. 6d. net.

THIS book is well suited for the use of older students of chemistry who require a fairly advanced treatise on quantitative analysis, including volumetric, gravimetric, and physico-chemical processes. It is a book which will be found even more useful out of than in the laboratory, for the theories involved in analytical work are particularly thoroughly explained, and the student who uses it is required to do a considerable amount of careful reading. The introductory chapters deal with the nature and properties of solutions, the factors which determine equilibrium, methods of producing and applying heat, &c. Each section of the practical part opens with a general account of the theory of the processes grouped together, and in the descriptions of the practical work the systematic plan is adopted of first discussing the facts upon which the method is based, then describing the procedure, and finally giving questions and problems on it. Special attention is paid to sources of error, and many practical problems are given. In the second edition some parts have been expanded where experience has shown that it is desirable, and answers to many of the more complicated numerical problems have been added.

OBITUARY.

JOHN SCUDAMORE SELLON.

MR. SELLON, whose death at the age of eighty-one took place on the 18th instant, in London, was born in 1836, fifth son of Capt. William Baker Sellon, R.N. At an early age he joined the well-known business house of Johnson, Matthey, & Co., Assayers and Refiners to the Bank of England and Royal Mint, Metallurgists, &c., founded by his uncle, Percival Norton Johnson, in 1822.

He played a prominent part in the researches and industrial developments connected with the platinum and other groups of rarer metals, with which the name of his firm is closely associated; indeed, the now numerous and important commercial applications of platinum and its allied metals may be said to be chiefly due to the initiative and efforts of himself and his co-workers, George and Edward Matthey.

During the concluding quarter of last century he also took an active share, both in the fields of technical discovery and industrial development, in the then new sphere of electrical engineering, and was associated with Faure, Brush, Swan, Lane-Fox, Volckmar, and others in their early work on electric lighting and storage.

He married in 1858 Fanny Maria, daughter of Captain Thomas Alexander Souter, 44th Regiment, who survives him.

CHEMCIAL NOTICES FROM FOREIGN SOURCES.

NOTE.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxv., No. 20, November 12, 1917.

This number contains no chemical matter.

No. 21, November 19, 1917.

Pyrogenous Decomposition of Methyl Alcohol at a High Temperature.—Eglantine Peytral.—When a rapid current of methyl alcohol vapour is passed through a platinum tube heated to about 1150° the primary products are formaldehyde and hydrogen, according to the equation $CH_3OH = HCHO + H_2$. The formaldehyde subsequently decomposes to give carbon monoxide and hydrogen, $KCHO = CO + H_2$.

No. 22, November 26, 1917.

Manufacture of Silica Bricks.—H. le Chatelier and B. Bogitch.—Silica bricks were made from different proportions of large quartz grains (4 mm.), fine quartz grains (0·1 mm.), or impalpable powder (0·01 mm.), and their resistance to crushing was determined. It was found that the substitution of fine quartz for the impalpable powder very considerably reduced the resistance to crushing measured at 1600°. 75 per cent of crude quartz to 25 per cent of the impalpable powder and 2 per cent of lime gave the best results. The resistance to crushing measured at 1600° and when cold do not agree.

MISCELLANEOUS.

Non-adhesivity and the Dropping of Berries.—Surface tension, the unequal evaporation of several liquids, and surface condensation on solids can explain the dropping of berries. By gelatinising celluloid, acetic acid, alcohol, and ether to no further visible evaporation, at normal temperature and in a wide-mouthed bottle in which some locust berries are shaken, it will be found that they do not adhere permanently, but drop after a minute or so to the bottom of the bottle. The conditions of adhesion are neither those of that of plane surfaces or perfect vacuum, but a continuity of surface tension conditions and of condensation.—J. C. THOMLINSON, B.Sc.

Society of Chemical Industry (London Section.)—The next meeting has been arranged as a meeting of London chemists held under the auspices of the Section to consider and discuss the proposed formation of a British Association of Chemists. The meeting will be held at the rooms of the Royal Society of Arts, John Street, Adelphi, W.C., on Monday, February 4th, 1918, at 7.30 p.m. Steps have been taken in Manchester, Birmingham, Liverpool, and other centres, towards the formation of a British Association of Chemists, and it is accordingly considered desirable that an opportunity should be arranged for London chemists to discuss the proposal. It is hoped that representatives of the promoters of the proposed association and of the Institute of Chemistry will attend the meeting. As it is desired to make the meeting as representative as possible, and as it is difficult to communicate directly with all chemists in the London district, I shall be glad if you will kindly inform any chemists who are not members of the Society that the committee of the section will welcome their attendance at the meeting.—STEPHEN MIALL, Hon. Secretary, 28, Belsize Grove, Hampstead, N.W.3.

NOTES AND QUERIES.

Solutions Exhaling Oxygen.—Can any reader furnish information regarding the following:—The names of two common substances which when dissolved in water exhale oxygen; or two substances which inhale oxygen and exhale it into water?—R. B.

MEETINGS FOR THE WEEK

MONDAY, 4th.—Royal Society of Arts, 4.30. (Cantor Lecture). "High Temperature Processes and Products," by C. R. Darling.
— Royal Institution, 5. (General Meeting).

TUESDAY, 5th.—Royal Institution, 3. "Problems of British Anthropology," by Prof. Arthur Keith.
— Royal Society of Arts, 4.30. "The Industrial Resources of South Africa," by C. du P. Ceiappini.
— Röntgen Society, 8.15. "Simple means of obtaining 'Static Currents' from an Induction Coil," by Dr. G. B. Batten. "A Mobile Shock Apparatus," by T. E. Burnside.
— Institution of Civil Engineers, 5.30. "The West Quay of Madras Harbour," by Hon. Sir Francis J. E. Spring and H. H. Gordon Mitchell.

WEDNESDAY, 6th.—Royal Society of Arts, 4.30. "The Development of the Mineral Resources of the Empire," by Prof. W. Frecheville.
— Society of Public Analysts, 5. (Annual General Meeting). "A Modified Acetic Acid Reagent for Valenta Tests," by A. E. Parkes. "Oiticica Oil—a New Drying Oil," by E. R. Bolton and C. Revis.

THURSDAY, 7th.—Royal Institution, 3. "Illusions of the Atmosphere the Travelling Vortex and the Cyclonic Depression," by Sir Napier Shaw.
— Royal Society. "Photo-electric Action of X-Rays," by O. W. Richardson. "The Parent of Actinium," by F. Soddy and J. A. Cranston. "Absorption of the Radiation emitted by a Palladium Anticathode in Rhodium, Palladium, and Silver," by E. A. Owen.

FRIDAY, 8th.—Royal Institution, 5.30. "Science and Ethics," by Principal E. H. Griffiths.

SATURDAY, 9th.—Royal Institution, 3. "The Ethics of the War," by M. P. H. Loyson.

TO comply with Regulation 8 (b) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

A Chinese Graduate, B.Sc. (London University), seeks Position as Chemist, either in Analytical or Manufacturing work.—Write, Y. T. C., care of 2, Kingston House, Fortess Road, Kentish Town, London, N.W. 5.

ANALYTICAL CHEMIST.—Required for routine work on Alloy Steels, smart Junior Assistant. No person already on Government work will be engaged.—Apply, your nearest Employment Exchange, mentioning No. A 4515.

Chemist, intelligent, elderly, at present employed in large Government Steel and Copper Works in Russia, seeks employment in this country.—Messrs. Symonds and Macdonald, Writers, Dumfries, N.B., will furnish all particulars.

Cement Works Chemist wanted for India. Liberal terms to capable man.—Write, stating experience and salary required, to "Cement," care of Street's, 30, Cornhill, London, E.C. 3.

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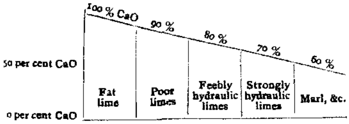
ANCIENT AND MODERN MORTAR.*

By W. J. DIBDIN, F.I.C., F.C.S.

THE comparison between ancient and modern mortars presents many points of interest, amongst which may be more particularly mentioned the quantity of lime used in proportion to aggregate, the character of the aggregate, and the presence of clay. The quantity of soluble silica in some mortars has been quoted as proof of the action of the lime on the flint in the aggregate, but as will be seen later on, this is entirely fallacious. The strength of certain old mortars has been quoted as if the users possessed methods the art of which has been lost, but there is no evidence that such is the case, as properly compounded modern mortars will within a reasonable time possess strength equal to the best old samples obtainable.

The work carried out by the author for the Science Committee of the Royal Institute of British Architects during the years 1907-8-9-10, following a paper read by him before that Institute in December, 1906, on "The Composition and Strength of Mortars," brought to light many points which had hitherto been but vaguely dealt with.

An important point is that relating to the quantity of lime used. It appears a simple statement to say to "1 to 3," *i.e.*, one volume of lime to three of sand. In practice this appears to have been read in different ways. In some instances the volume of lime is measured as dry unslaked lime as received from the kiln. In others the lime has been first "dry-slaked," and the required quantity taken from the powdery mass, which has a volume per unit weight of unslaked lime greater than that originally. In some cases the slaked lime is first made into a "putty," kept for a time, and then measured in that condition. For instance, in one case 1 cub. ft. of unslaked lime, after slaking, equalled 1·53 cub. ft., and in another the cubic foot was increased to 1·77, whilst still greater variations have been observed. Hence all statements of proportions of lime to aggregate are generally given in terms of *unslaked* lime, and in stating the results of analyses of mortar the volume of lime is calculated from the percentage of pure CaO on the assumption that the original lime was comparable to a commercial lime containing 80 per cent CaO, and multiplying the weight so found by 2½, to correct *weight to volume*. This is necessary an arbitrary rule, but it is the only one available, and serves for practical purposes in the absence of definite information. The variation in the qualities of various limes may be diagrammatically shown thus—



Proportion of Lime in Ancient Mortar.—The analysis of a series of ancient mortars collected for the purpose of the investigation above referred to, by members of the Royal Institute of British Architects and others, the results of which are given at length in the Report to the Science Committee of the Institute, showing that the volume of aggregate to 1 volume of lime varied from 0·4 to 3·7, but in only four instances out of twenty-six was it more than 2, the average of these being about 1, as compared with the modern practice of 3. The best results of a large number of mortars prepared for experimental purposes and kept two years before being tested for crushing and tensile strengths, showed, out of 15 samples, that 11 contained 2·0 to 2·5 of aggregate to 1 of lime. Unfortunately, tests with 1 to 1 were not made. It will, therefore, be seen that in the matter of relative volume the ancient mortars contained larger quantities of lime than is considered permissible in modern practice.

Nature of the Aggregate.—Modern specifications of the aggregate to be used for mortar generally state that this is to be "clean, washed sand, &c." On turning to the results of the analyses of ancient mortars of the twelfth and thirteenth centuries, and that of the London Wall, we find that the proportion of aggregate was not only less, but its character was largely that of gravelly sand with clean ferruginous clay, the quantity of the clay varying up to as much as 19·5 per cent of the aggregate.

The samples of mortar from Allington Castle, early thirteenth century, collected by Mr. W. D. Caroe, F.R.I.B.A., were particularly interesting. The relative proportions of lime to sand, &c., in three samples were 1 to 1·7, 1 to 1·1, and 1 to 1·9, the observations of Mr. Caroe when sending them being respectively, "Very good indeed," "Not so good as A, but fair," and "In fair condition." The percentage of clean ferruginous clay was respectively 8·6, 3·66, and 4·0 per cent on the sand, which was fairly coarse, the proportions of coarse sand retained on a ½-inch mesh being 20, 22, and 12 per cent respectively. The crushing strength of the first of the three samples was as high as 144 lbs. per cubic inch, and that of the second 90 lbs. Two other samples from the same building contained lime in the proportions of 1 to 1 and 1 to 1·3; clean red clay in the proportion of 4·5 and 5·7 per cent of the aggregate, respectively; the crushing strength being 162 lbs. and 194 lbs. per cubic inch respectively.

Two samples of Roman mortar, viz., from the Pharos, Dover, and a Roman villa at Darenth, contained clean lime and broken brick only; whilst another from Threlfall Castle, near Hythe, contained clean flint and pebbles for the aggregate.

Thus we see that there was no systematic method in the preparation of these early mortars, evidently materials most conveniently obtainable being employed, preference, however, being given to clean ferruginous, clayey, gravelly sand when obtainable.

As showing the character of some of the mortar used after the Fire of London a sample from Painters' Hall, Trinity Lane, is interesting. This was built by Sir Christopher Wren, who evidently had little time to look after details. The sample was collected by Mr. H. D. Searles-Wood, F.R.I.B.A., and was found to contain lime and grit in the proportion of 1·0 to 0·5. There can be little doubt that a good proportion of this lime was due to the use of old mortar. It was unequally mixed, and contained lumps of lime, some soft and some hard, the "sand and grit" consisting of broken red brick and organic debris, evidently old rubbish from the ruins of the Fire, the "earthy matter," clay, &c., in the grit being no less than 15·4 per cent. In this case the crushing strength was 110 lbs. per cubic inch.

In comparison with these results we may now turn to the best results obtained with experimental samples of mortar made with known materials and in proportions of lime to aggregate varying from 1 to 2 up to 1 to 5, and tested after being kept for two years (Table I.).

These results show distinctly the reason of the advantage gained by the early builders in fixing their ratio at about 1 to 2, and the use of a coarser aggregate, as we have seen. The modern rush after economy, by reducing the quantity of lime, is very largely responsible for the falling off in quality.

* A contribution to a General Discussion on "The Setting of Cements and Plasters," held before the Faraday Society, January 14, 1918.

TABLE I.

	Ratio.		Lb. per cub. in.
White chalk lime gave the best results with—			
Standard Leighton Buzzard sand..	1 to 3	=	240
Fine Charlton sand	1 „ 2	=	300
Pit sand	1 „ 2	=	247
Thames sand	1 „ 2	=	297
Ground brick	1 „ 3	=	312
Dorking Greystone lime gave the best results with—			
Standard Leighton Buzzard sand..	1 „ 2	=	257
Charlton fine sand	1 „ 5	=	180
Pit sand	1 „ 2	=	333
Thames sand	1 „ 2	=	243
Ground brick	1 „ 3	=	162
Blue Lias lime gave the best results with—			
Standard Leighton Buzzard sand..	1 „ 2	=	538
Charlton fine sand	1 „ 2	=	257
Pit sand	1 „ 3	=	650
Thames sand	1 „ 2	=	785
Ground brick	1 „ 2	=	910

With regard to the presence of clay in the "sand grit," this has received attention. Unfortunately, the experiments were made with ratio of 1 to 3 in all cases, so the results do not compare with the foregoing, but as comparable tests were made with and without the addition of 5 per cent Red London clay they are not without interest (Table II.).

TABLE II.—*Ratio 1 to 3. Crushing Strength in lbs. per cubic inch.*

	Without Clay.	With 5 per cent. London Clay.
White chalk lime and—		
Standard sand	240	230
Fine Charlton sand	260	70
Pit sand	253	163
Dorking Greystone lime and—		
Standard sand	228	177
Fine Charlton sand	140	82
Pit sand	200	140
Blue Lias lime and—		
Standard sand	188	876
Fine Charlton sand	156	79
Pit sand	650	550

From these results it will be seen that the use of clay when the proportion of matrix to aggregate is 1 to 3 is disadvantageous with white chalk lime and greystone lime, but with blue lias lime a marked improvement is obtained with the Standard sand.

Under other conditions the use of clay is distinctly advantageous. For instance, greystone lime and Standard sand were used in varying proportions, and the blocks crushed at the end of one month, with the results given in Table III.

TABLE III.—*Crushing Strength in lbs. per cubic inch.*

Standard sand—		
Without clay, 5 vols., lime 1 vol...	=	42
+ 2½ per cent clay, 5 vols., lime 1 vol. ..	=	74
+ 5 per cent clay, 5 vols., lime 1 vol. ..	=	128
+ 7½ per cent clay, 5 vols., lime 1 vol. ..	=	183
+ 10 per cent clay, 5 vols., lime 1 vol. ..	=	176
+ 10 per cent clay, 2 vols., lime 1 vol. ..	=	223
Lewisham fine sand and natural clay 3 vols., lime 1 vol..	=	154
Lewisham fine sand washed free from clay 3 vols., lime 1 vol	=	33

Voids in Aggregate.—An essential factor in regard to the strength of mortar is that relating to the voids, or empty spaces, between the particles. In the case of a mortar made with a sand having 40 per cent of voids the crushing strength was found to be only 70 lbs. per cubi inch, whilst with a sand having only 23 per cent of void the crushing strength was 154 lbs. This explains why th proportion of lime, when used with coarse sand, shoul be in a greater ratio than 1 to 3. 1 to 2 giving far bette results.

The suggestion that soluble silicates are formed in th course of time is not borne out in the author's experienc As a test case, a mortar was made with pure lime and clea sand treated with hydrochloric acid and thoroughl washed. After twelve months it was carefully examine for soluble silica, when not a trace was present. The ex amination of numerous samples of ancient mortar reveale the presence of no more soluble silica than is normall found in ordinary fresh-made mortar. For instance, th mortar from the Roman Wall, London, contained only 0·3 per cent; those from Allington Wall, twelfth an thirteenth centuries, only 1·20, 0·70, 1·00, 0·42, 0·84, an 0·68 respectively, and that from the Pharos, Dover, onl 0·30 per cent. Certain cases are met with in which th soluble silica is much higher, as at Pembrey Castl Caermarthen, thirteenth century, where the soluble silic was as much as 2·95 per cent, and the core of the old wa at Crosby Hall, where 3·8 per cent was found. Muc higher results have been obtained, but in such instance the character of the mortar leads to the conclusion tha trass or pozzuolan, &c., had been employed.

The setting of mortar was ascribed by Graham to th fact that "on drying the mortar binds the stones betwee which it is interposed, and its own particles cohere so a to form a hard mass solely by the attraction of aggrega tion, for no chemical combination takes place between th lime and the sand, and the stones are simply united a two pieces of wood are by glue." "From the minut division of the silica and alumina in hydraulic mortar their combination with lime is more likely to occur tha in ordinary mortar. Still the fixing of the hydrauli mortar seems to be chiefly due to the fixation of the wate and formation of a solid hydrate like gypsum." This vie entirely agrees with my own experiments, as recite shortly in the foregoing, and I have no doubt that th process of crystallisation acts largely in connection wit the "setting" of mortar and cement, assisted by aggrega tion.

THE CONSTITUTION AND HYDRATION OF PORTLAND CEMENT.*

By A. A. KLEIN (Worcester, Mass.).

PORTLAND cement may be defined as the product produced by pulverising to a sufficient and definite fineness the clinker obtained by an incomplete fusion of a finely ground intimate mixture containing essentially lime, silica, and alumina in certain definite proportions. Iron, magnesium, sodium and potassium oxides are present almost universally in the product, although in the light of recent investigations indications are that these are not at all essential.

Constitution of Portland Cement.

The "whys and wherefores" of cements have been the subject of research and speculation for over one hundred years. Even before Joseph Aspdin took out a patent on the hydraulic lime he called Portland cement, Vicot in France had started his important investigations on the relation of the chemical composition of the stone used as a raw material to the quality of the product derived, on the nature of the constituents produced on burning, and on the chemical and physical reactions involved when limes and cements set and harden with water. Although some of his deductions were proved erroneous by later in-

* A contribution to a General Discussion on "The Setting of Cements and Plasters," held by the Faraday Society, January 14, 1918.

vestigators, many of them are known to be true. He became aware of the fact that the hardening of cement was unlike the hardening of lime in that carbonation of the lime present in cement was not essential to its hardening. He believed likewise that in hardened mortars at least some of the lime was in combination with other oxides besides water, and regarded silica as being the most important one.

Little progress was made in cement investigation for many years after Vicot, although improvement in grinding and burning really revolutionised the product by bettering its quality and uniformity. Progress was made by "hit-and-miss" methods, since no information was forthcoming concerning the chemical reactions involved in the burning of the clinker and in the setting of the resultant cement.

This was largely due to the inadequacy of purely chemical methods as a tool of research. A turning-point was reached when Tornebohm and Le Chatelier, working practically simultaneously, employed the petrographic microscope to decipher the constituents of cement clinker and set cement. They were able to identify materials of different optical properties by examining thin sections. For instance, Tornebohm found four constituents which he called alite, belite, celite, and felite. Of these he considered alite the most hydraulic material, and responsible to a great degree, if not wholly, for the peculiar properties of cement. Neither Tornebohm nor Le Chatelier were clear as to the chemical nature of the products they found, nor is Tornebohm's distinction between belite, celite, and felite very lucid. He observed that the amount of alite increased with an increasing lime content. Le Chatelier thought the compound he found which was identical with Tornebohm's alite to be a mixture of tricalcium silicate and tricalcium aluminate.

The application of the polarising microscope proved an impetus to research on the constitution of cement, and there subsequently appeared several works and several conflicting opinions as to the nature of the minerals found, particularly alite. The reason for this is very apparent when one considers the qualitative petrographic methods used. Firstly, a thin section is practically useless in thoroughly distinguishing between these minerals. It is impossible to obtain a section much thinner than 0·03 mm. even in the most favourable material. Let us now consider that Portland cement is obtained by a process of sintering and partial fusion, that quick cooling is practised to prevent dusting of the clinker, and that the crystals of the compounds themselves formed under the most favourable conditions are very minute and poorly developed and rarely reach a few hundredths of a millimetre in length. With these facts in mind it is readily seen that in Portland cement practice the conditions for coarse crystallisation is nil, and it follows that owing to the fineness of crystallisation invariably there was overlapping and superimposing of crystallites above others in the thin sections, making the optical observations very indistinct.

Another point, and one which is just as important, was the application of comparatively crude optical tests resulting in the obtaining of rough data. Most of the recent methods for obtaining more accurate quantitative optical constants of artificial products by microscopic methods involve immersed grains. Let us consider that important constant, index of refraction. It is impossible with a thin section to ascertain it more accurately than one in the first decimal place, whereas with immersed grains it may be obtained at least with Portland cement minerals to within an accuracy of 0·003. When one considers the slight optical distinction between tricalcium-silicate and tricalcium-aluminate, two compounds always present in cement, it requires little imagination to see why mixtures of them should have been regarded as homogeneous.

Accordingly, then, there were in general three types of theories concerning the active principle of cement: (1) That it is a solid mutual solution of various calcium silicates and calcium aluminates to which each investigator ascribed formulæ; (2) that it is a definite lime, silica, alumina compound; and (3) that Portland cement is composed of separate silicates and aluminates some or all of which are hydraulic.

There was a time, even very recently, when the solid solution theory was most universally held. In Germany, Tornebohm, Michaelis, and Shott, among others, came to this conclusion, likewise Glasenapp, at Riga. In the United States, Clifford Richardson (*Cement*, 1903, iv., 276) published the results of an exhaustive study, and concluded that the clinker consisted essentially of a solid solution of tricalcium aluminate in tricalcium silicate. He later, however, admitted the error of his conclusions, due, of course, to the inability of older petrographic methods to decipher extremely fine crystalline products.

Of the investigations which appeared to prove the existence of a ternary compound occurring universally in cement, that of Ernest Jänecke was the most comprehensive and scientific (*Zeit. Anorg. Chem.*, lxiii., 200; lxxiv., 428). The petrographic description of his supposed compound, $8CaO$, Al_2O_3, $2SiO_2$, was very qualitative and meagre. The optical constants were not even approximately determined, so that as a basis of comparison with constituents now known to be in cement this description was useless. At any rate, investigations at the Bureau of Standards and at the Geophysical Laboratory concerning the compound $8CaO$, Al_2O_3, $2SiO_2$ have invariably shown that it does not exist, and that a melt of its composition generally crystallises as $3CaO$, SiO_2, $2CaO$, SiO_2, and $3CaO.Al_2O_3$.

Finally, of the investigations which led to the conclusion that cement is composed of separate silicates and aluminates, that of the Geophysical Laboratory on the binary systems $CaO-SiO_2$, $CaO-Al_2O_3$, $Al_2O_3-SiO_2$ and on the ternary system $CaO-SiO_2-Al_2O_3$ has done most to unravel this problem. In the preliminary report on the ternary system the constituents of the clinker were enumerated as follows (*Journ. Ind. Eng. Chem.*, iii., 1):—

"Portland cement clinker within the concentration limits set by Richardson when in equilibrium may exist in the following combinations depending primarily upon relatively small changes in the quantity of lime present:

I.	CaO	$3CaO.SiO_2$	$3CaO.Al_2O_3$
II.	$3CaO.SiO_2$	$2CaO.SiO_2$	$3CaO.Al_2O_3$
III.	$2CaO.SiO_2$	$3CaO.Al_2O_3$	$5CaO.3Al_2O_3$.
IV.	$2CaO.SiO_2$	$5CaO.3Al_2O_3$	$CaO.Al_2O_3$
V.	$2CaO.SiO_2$	$2CaO.Al_2O_3.SiO_2$	$CaO.Al_2O_3$

"Richardson's typical cement corresponds to class II." Furthermore, "If solid solutions are formed, they are very limited in extent, and are not sufficient to affect the optical properties of either silicate, the lime, or the aluminate."

Shortly after this report appeared the Bureau of Standards began an investigation of the constitution of cement, using the optical methods employed at the Geophysical Laboratory for deciphering the constituents. Raw material mixtures which gave clinkers of various diversified chemical compositions were made and studied. *Many of these were outside the limits used in cement* practice. Different series of clinkers were produced in which, considering MgO with CaO and Fe_2O_3 with Al_2O_3, one oxide was approximately constant and the other two varied ("*Concrete-Cement Age*," *C.M.S.*, p. 3, January, 1913). Practically all the predictions of the Geophysical Laboratory were verified. Portland cement within the composition limits considered good practice was found to be a mixture of β $2CaO$, SiO_2, $3CaO.SiO_2$, and $3CaO.Al_2O_3$. Of the three, β $2CaO.SiO_2$ occurs in the greatest amounts. CaO does not occur except in underburned clinker, and the presence of $5CaO.3Al_2O_3$ may result from underburning or from raw material mixture low in lime and high in alumina. Class I., as given in the Geophysical Laboratory report, was never found in the cements even of highest lime content, and it was dis-

covered that a material of such a composition must be burned at high temperatures which could not be economically produced. Furthermore, later investigation on the hydration of cement established the undesirability of the presence of free lime in the finished product.

Class II. is typically good cement. The constituents of class III. were found in abnormally low-limed cements. In all cases of cements of this type "dusting of the clinker" was a serious and frequent occurrence, and oftentimes the yield of undusted clinker was very small. The setting of cements of this class was generally erratic, and the strengths below normal. Classes IV. and V. were never found in Portland cement.

The phenomena occurring when a mixture of class II. is heated is given in a later work by Rankin (*Journ. Franklin Institute*, June, 1916). Although his observations were made only on the pure oxides, they apply to the burning of Portland cement, except that owing to the presence of Fe_2O_3, MgO, Na_2O, and K_2O in the latter the eutectic temperatures are noticeably lower. Rankin says: "For this purpose, let us follow the reactions which take place when a mixture whose composition is CaO 68·4 per cent, Al_2O_3 8·0 per cent, and SiO_2 23·6 per cent, is slowly heated. This mixture, made up only of the pure oxides lime, alumina, and silica, when properly burned will produce a good Portland cement. When such a mixture is heated, the first change is the evolution of the CO_2; the lime then unites with the other components to form the compounds $5CaO.3Al_2O_3$ and $2CaO.SiO_2$ probably in the order named, since the former has a lower melting-point than the latter; subsequently these two compounds unite in part with more lime, and the compounds $3CaO.Al_2O_3$ and $3CaO.SiO_2$ appear. This formation of the last two compounds, a process which goes on very slowly in mixtures of their own composition, is materially facilitated by the circumstance that in the ternary mixtures a portion of the charge has already melted and promotes reaction by acting as a flux or solvent. The temperature at which this flux first appears is 1335° C., the eutectic temperature for the three compounds $2CaO.SiO_2$, $5CaO.3Al_2O_3$, and $3CaO.Al_2O_3$. As the temperature of burning gradually rises above 1335° the relative amount of flux increases, and the rate of formation of $3CaO.Al_2O_3$ and $3CaO.SiO_2$ increases accordingly. At a temperature somewhat above 1335° the compound $5CaO.3Al_2O_3$ will have completely melted in the flux, and the formation of $3CaO.Al_2O_3$ is complete. The substances present as crystals at this stage are $3CaO.SiO_2.Al_2O_3$, $2CaO.SiO_2$, and free CaO. As the temperature is raised still further the amount of flux increases and the rate of combination of $2CaO.SiO_2$ to form $3CaO.SiO_2$ increases. For finely-ground raw materials of the above composition a temperature of about 1650° C. is required for burning."

The foregoing is, of course, accurate in the case of pure oxides, and Rankin does note the effect on the burning temperature of the presence of the other common oxides. As a matter of fact, investigation by the Bureau of Standards has shown that the burning temperature of the commercial product varies within wide temperature limits. It is possible to obtain a raw material mix which will give a cement passing specifications when burned at 1250° to 1300°. This is accounted for, of course, by the fact that in systems involving the same components in general the greater the number of components contributing to a eutectic the lower will be the eutectic temperature. Thus, instead of the flux appearing at 1335°, the eutectic temperature of $2CaO.SiO_2$, $5CaO.3Al_2O$, and $3CaO.Al_2O_3$ as noted by Rankin, clinkers containing $3CaO.SiO_2$ have been burned at less than 1300°. In this case the eutectic was probably the one between the above compound as well as MgO, Fe_2O_3, Na_2O_3, Na_2O, and K_2O compounds or solid solution products.

To recapitulate, the constituents of perfectly burned Portland cement are $2CaO.SiO_2$, $3CaO.SiO_2$, and $3CaO.Al_2O_3$. Alite of earlier investigators was apparently a mixture of the latter two compounds; and celite was probably $2CaO.SiO_2$ or an intimate mixture of $2CaO.SiO_2$ and $3CaO.Al_2O_3$. In actual practice, free lime is usually present in small quantities, and is the constituent which must be blamed when a cement is not volume constant. The compound $5CaO.3Al_2O_3$ may also be present, but is not at all derogatory. Of the minor oxides a portion of the Fe_2O_3 exists in the cement colouring the compound $2CaO.SiO_2$, but the action between them is not entirely understood. The remainder occurs usually as a reddish nearly opaque to black opaque isotropic flux material which sometimes is reduced sufficiently enough to show magnetic properties. Magnesia has been shown by the Bureau of Standards to replace the lime in the silicates and aluminate up to a certain concentration beyond which Spinel ($MgO.Al_2O_3$) and Monticellite ($MgO.CaO.SiO_2$) are formed (Original Communications, 8th International Congress of Applied Chemistry, v., p. 73). It was also noted that if properly burned, cement could contain 7—8 per cent MgO without being affected deleteriously ("Concrete-Cement Age," *O.M.S.*, p. 706, September, 1914).

(To be continued).

THE VISCOSITY OF BLAST-FURNACE SLAG AND ITS RELATION TO IRON METALLURGY, INCLUDING A DESCRIPTION OF A NEW METHOD OF MEASURING SLAG VISCOSITY AT HIGH TEMPERATURES.*

By ALEXANDER L. FEILD, B.A., M.S. (North Carolina).
Assistant Metallurgist, United States Bureau of Mines, Pittsburgh, Pa.

(Continued from p. 56).

Description of Furnace and Accessories.

The electric furnace used in the experiments of the author is of the granular carbon resistance type, and is similar as regards the arrangement of resistor and supporting refractories to the one described by Jefferies (83). The arrangement of the furnace and its accessories are shown in Plate I. (which, with others, appear in the original reprint of the Paper).

The heating zone is comparatively large—3 in. in diameter and 6 in. long—and consequently required very efficient heat insulation of the cylindrical part of the heating zone, and also of the circular ends. The maintaining of high temperatures for a comparatively long period necessitated making the furnace air-tight by means of an external sheet-iron shell to protect the resistor from oxidation and prevent excessive generation of carbon monoxide. Exclusion of the atmosphere from the interior of the furnace was also necessary to protect the graphite crucible and viscosity spindle. In order to afford an easy means of renewing the granular resistor, inspecting the interior of the furnace, and introducing the graphite crucible containing the slag sample, the sheet iron shell is divided horizontally along a plane which cuts the top of the heating zone. When the furnace is in use the upper part, which is removable, is bolted to the stationary lower part along machined flanges provided with asbestos gaskets. The outer furnace shell is 18 in. long, over all, and 14 in. in diameter. The heating zone occupies a central position within the shell. Electrical connection is made with graphite ring electrodes by means of graphite rods enclosed in a sheet-iron sheath. The graphite core of these electrode connectors is threaded into the electrodes proper. The connectors are continued through the sheet-iron shell, and connected externally with the leads from the transformer, being insulated from the shell by means of asbestos packing. The outer ends of the connectors are water-cooled to prevent heat troubles.

* A Paper communicated to the *Transactions of the Faraday Society*. Published by permission of the Director, U.S. Bureau of Mines

The resistor material used in these experiments was granular carbon, although "cryptol" or graphite could be used as well. The granular carbon as obtained is screened to approximately 20-mesh size.

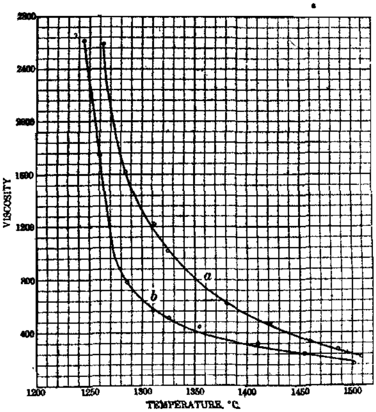


Fig. 1.—Temperature-viscosity relations of two synthetic slags.

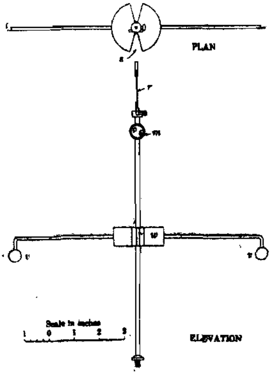


Fig. 3.—Upper part of suspension system—*m*, mirror; *r*, steel suspension ribbon; *s*, open sector; *w*, weight; *vv*, vanes.

The inner and outer refractory tubes which enclose the resistor material are of Norton alundum. Both glazed and unglazed tubes have been used without any particular difference in their behaviour being noted. The inner and outer tubes must be renewed at intervals, owing to cracking, which apparently cannot be avoided even with slow rates of heating and cooling. The life of the alundum is considerably prolonged if the furnace is not

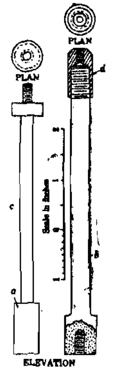


Fig. 2.—Viscosity spindle and connecting rod. Left view, viscosity spindle—*a*, graphite spindle; *c*, spindle shaft. Right view, connecting rod—*b*, graphite rod; *d*, steel connecting collar.

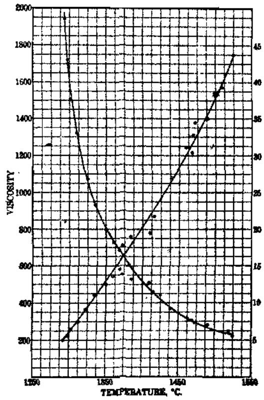


Fig. 4.—Temperature-viscosity relations of an artificial diopside.

heated to temperatures above 1500° C. The alundum heating tubes are immediately surrounded by magnesite chips, which in turn are insulated by kieselguhr from the outer shell. The end parts of the furnace are insulated

with kieselguhr, which is protected where exposed to the intense heat of the heating zone by a layer of Northrup cement placed over a 20-mesh magnesite.

As the upper part of the furnace was made removable, it became necessary to find a means of supporting the kieselguhr without introducing any fusible or heat-conducting material. Asbestos and transite (84) board were tried, but immediately deteriorated because of dehydration and elimination of the binding material. Accordingly, fire-clay cylinders were placed both above and below the heating element, and the upper fire-clay cylinder was bolted to the top of the upper removable cylinder by means of lag screws. The kieselguhr packed between the fire-clay ring and the outer shell was prevented from falling out by covering the surface with a layer of Northrup cement.

The furnace is supported vertically by a tripod bolted to the sheet-iron shell, the bottom of the furnace being 22 in. above the floor of the room. A support is bolted to the upper removable shell, to which the optical pyrometer is attached when the furnace is in use.

Rotating Device.—A ⅞-in. steel shaft, by means of which the cylindrical crucible containing the slag is rotated, projects up into the furnace through a stuffing-box placed centrally in the base of the sheet-iron shell. The lower end of the shaft is supported on a bearing fixed to the tripod. The steel shaft extends only a short distance beyond the bottom of the furnace shell, and is bored for the reception of a slightly smaller supporting rod of Acheson graphite. This supporting rod is threaded at its upper end for the reception of the graphite slag crucible (Plate II.), the graphite rod being tapered at its upper end to a diameter of ⅜ in. in order to eliminate, as far as possible, conduction of heat from the crucible. The crucible possesses an inside diameter of ⅞ in. and an inside depth of 3 in., with a thickness of wall of ¼ in. The bottom of the crucible is ½ in. thick, so that the rod may be firmly threaded into it. The supporting rod fits snugly into the hole in the axis of the steel shaft to a depth of 2½ in., and its length between the top of the steel shaft and the bottom of the crucible is about 6 in. In the earlier experiments with the method it was thought necessary to introduce a Marquardt porcelain rod between the crucible and the steel shaft to prevent excessive heat conduction. A graphite rod tapered down to a diameter of only ⅜ in. has been used without excessive heat conduction being noted. This device also eliminates the undesirable experimental feature of using a brittle porcelain part in the supporting system.

Source of Heat.—The heating current is supplied by a transformer equipped with an adjustable panel which gives voltages ranging from 40 to 100 volts in steps of 2 volts. The maximum power input amounts to slightly over 5 kilovolt ampères and the maximum current to 110 ampères.

Furnace Atmosphere.—The normal atmosphere of the furnace is a mixture of carbon monoxide and nitrogen, corresponding to that in the hearth of the blast-furnace.

Viscosity Apparatus.—Acheson graphite seems to be the only refractory available for such use as that of high-temperature viscosity measurements on blast-furnace slag. An apparatus or crucible made of platinum would be rapidly destroyed in such a furnace atmosphere, especially as all slags contain considerable quantities of sulphur and small amounts of iron. Of the various refractory oxides generally used, zirconia, the refractory properties of which are described by Meyer (85), comes nearest to fulfilling the necessary conditions, because it is not improbable that a refractory mixture may be made from it that will not flux appreciably with the molten slag. Such a refractory, however, was not available when these experiments were performed.

Acheson graphite possesses the advantages of having a very low coefficient of expansion, a relatively great mechanical strength at high temperatures, desirable working properties, and shows inappreciable alteration on being kept for long periods at high temperatures. All of these properties are desirable for the construction of an apparatus which must of necessity preserve its shape and dimensions over a wide range of temperature. The action of the molten slag on the viscosity spindle immersed in it is so small that the radius of the spindle decreases only approximately 0·005 cm. during a viscosity determination. The action of the slag is perfectly uniform over the surface of the spindle, so that the same spindle may be used repeatedly, due allowance being made for the slight change in its radius.

The construction of the viscosity spindle and connecting rod is shown in Fig. 2. The large cylindrical part, *a*, at the base of the spindle (on the left of the figure) dips into the molten slag, while the upper part is threaded into the base of the connecting rod (shown in the right of the figure). This connecting rod is also made of graphite, except for the steel cap at its upper end, *d*, by means of which the connecting rod is in turn attached to the upper part of the suspended system shown in Fig. 3.

The distance from the surface of the slag to the bottom of the steel suspension (*r*, Fig. 3) is approximately 21 in. Such a system would not in itself be at all stable under the conditions of measurement. It was therefore necessary to place a weight of about 200 grms. between the suspension ribbon and the spindle at a point just outside the furnace shell and about 4½ in. below the suspension. This weight gives stability to the system, decreases the effect of vibrations upon the mirror, and holds the spindle in its position in the slag mass. Moreover, in order to further increase the inertia of the system about its longitudinal axis and to render the system aperiodic and practically non-susceptible to disturbing influences of short duration, the 200-grm. weight (see *w*, Fig. 3) is furnished with two diametrically opposite vanes (*v* and *v'*), which dip into cups filled with a viscous fluid such as castor oil, at a distance of about 4 in. from the axis of the system.

The mirror deflection is measured in the usual way by means of a telescope and scale.

The entire suspension system is fixed to a rod that projects horizontally from an apparatus support, firmly fixed to a heavy table and provided with a mm. scale for precise vertical adjustment of the apparatus. The furnace itself is first adjusted so that the steel shaft is in a vertical position, which ensures the alignment of the crucible also. The point to which the suspension system is fixed is then aligned by means of a plumb-bob with the axis of the shaft and crucible. In this manner the viscosity spindle is suspended centrally within the crucible.

The fluctuation rarely amounts to more than 1 per cent of the scale reading. It is probable that the mirror reading which is a measure of the viscosity of the slag is more precise than the reading of temperature in certain cases, although not as accurate.

The Measurement of Temperature.—The temperature of the slag was measured by means of an optical pyrometer of the Holborn-Kurlbaum type. The pyrometer is sighted directly upon the surface of the rotating slag through an open sector in the 200-grm. weight (see Fig. 3).

The pyrometer lamp and absorption prism that was regularly used in the experiments had been calibrated by the Reichsanstalt. As a check on this lamp, it was compared at intervals with another lamp, which also had been calibrated by the Reichsanstalt, but was used only for comparison. The readings in all cases coincided within the allowable error of observation. As a further check on the lamp and the absorption prism, simultaneous readings of temperature were made with the optical pyrometer mentioned and a Bureau of Standards thermo-couple (No. 443) in a furnace constructed in a manner similar to the well known "black-body" furnace of Lummer and Kurlbaum (86). Without the absorption prism the corrections were less than 10° for temperatures ranging from 1000—1200° C. With the absorption prism the following corrections were noted:—

Corrections for Temperature Readings.

Temperature °C.	Correction °C.
1200	38
1250	37
1300	40
1350	40
1400	43
1450	44
1500	50

As a check on the black-body conditions of the furnace used in the viscosity measurements, a sample of artificial diopside, $CaO.MgO.2SiO_2$, was prepared, and its temperature-viscosity relations determined in the same manner as adopted in the case of slags. This compound has a physical melting-point at 1392° C., and is converted, coincidently with its melting from a crystalline substance to a fairly fluid liquid.

The results of these measurements are given in Fig. 4. The viscosity curve bends quite sharply upward in the neighbourhood of the theoretical melting-point, the observed difference of about 20° C. being probably due to the fact that the artificial diopside did not have exactly the theoretically correct composition. Analysis of the artificial diopside gave the following composition :—CaO, 25·98 per cent; MgO, 19·48 per cent; SiO, 55·08 per cent. The correct composition is :—CaO, 25·84 per cent; MgO, 18·58 per cent; SiO_2, 55·58 per cent.

Notes.

83. Zay Jeffries, "Notes on the Gran-annular Electric Furnace," *Met. and Chem. Eng.*, 1914, xii., 154
84. Commercial product, consists principally of asbestos, mixed with a refractory binding material.
85. H. C. Meyer, "Zirconia, a New Refractory," *Met. and Chem. Eng.*, 1914, v., 791; "Further Notes on the Refractory Properties of Zirconia, 1915, vii., 263.
86. O. Lummer and F. Kurlbaum, "Der elektrisch geglühte 'schwarze Korper,'" *Ann. der Physik.*, 1901, v., 829.

(To be continued).

THE ORES OF COPPER, LEAD, GOLD, AND SILVER.

By CHARLES H. FULTON.

(Continued from p. 27).

Copper and Iron Sulphide Minerals Intermixed with considerable amounts of Gangue Minerals.

Butte, Mont.—The Butte, Mont., ore bodies are veins in an eruptive rock (monzonite). The ores are divided into two classes—first-class ore, which is smelted direct, and contains more than 3 to 4 per cent copper, and second-class ore, containing about 3 per cent copper, which is concentrated into an enriched product, the concentrate containing 10 to 15 per cent copper.

The copper minerals present in the ore are chalcocite, bornite, enargite, chalcopyrite, and covellite, associated with pyrite and sphalerite, and other sulphides and sulpho-arsenides, and sulphoantimonide minerals in small amounts. The gangue minerals are those of the associated rocks, chiefly monzonite. Named in the order of their importance, they are the felspars, andesine (a complex silicate of soda, alumina, and lime) and orthoclase, quartz, biotite mica, and hornblende). A typical chemical analysis of first-class ore is :—Copper, 8·60 per cent; iron, 18·25 per cent; zinc, 0·55 per cent; sulphur, 23·50 per cent; arsenic, 0·70 per cent; lead, trace; alumina, 6·15 per cent; lime, 0·30 per cent; magnesia, trace; silica, 39·30 per cent; silver, 3 ounces; and gold, 0·016 ounce, per ton. An analysis of the second-class ore is :—Copper, 3·25 per cent; arsenic, 0·37 per cent; antimony, 0·025 per cent; sulphur, 11·12 per cent; iron, 9·30 per cent; silica, 58·45 per cent; alumina, 11·90 per cent; lime, 0·15 per cent; magnesia, 0·25 per cent; potassa, 2·34 per cent; soda, 0·11 per cent; water, 0·15 per cent above 110° C. (C. W. Goodale and J. H. Klepinger, "The Great Falls Flue System and Chimney," *Trans. Am. Inst. Min. Eng.*, xlvi., 568). An analysis of the concentrate from second-class ore is :—Copper, 15·85 per cent; iron, 21·95 per cent; zinc, 0·50 per cent; sulphur, 29·10 per cent; manganese, trace; arsenic and antimony, 0·95 per cent; lead, trace; alumina, 3 per cent; lime, 0·45 per cent; magnesia, trace; silica, 26·50 per cent; silver, 5 ounces; and gold, 0·02 ounce, per ton. The average metal content of the Butte ores, as mined, is about 3·3 per cent copper, 2·5 ounces of silver, and 0·010 ounce of gold per ton. Butte production in 1914 was 236,805,845 pounds of copper, or 15·12 per cent of the United States production.

Bingham, Utah.—The ore bodies of the Highland Boy Mine, Utah, are lens-shaped, pyritous deposits in limestone. The ore consists of friable pyrite, with which is associated chalcopyrite and some bornite and chalcocite; small amounts of sphalerite and galena are found. The gangue is largely quartz with some silicate minerals present. The proportion of iron in the ore is 1 to 15 per cent greater than that of silica. A typical analysis of the ore is as follows:—Gold, 0·074 ounce per ton; silver, 1 ounce per ton; copper, 2·20 per cent; silica, 25·1 per cent; iron, 28·5 per cent; lime, 3·28 per cent; sulphur, 31·45 per cent; alumina, 1·37 per cent. The ore is roasted and smelted in reverberatory furnaces.

Bisbee, Ariz.—The Arizona ore bodies (Copper Queen mine) are replacements in limestone. The ores in the upper part of the ore bodies were oxidised ores, consisting of malachite, azurite, cuprite, and native copper as the main ore minerals. The chief ore at present is sulphide ore, although oxidised ore is still mined. The ore minerals in the sulphide ores are pyrite, containing chalcopyrite, chalcocite, and sometimes small quantities of bornite. A little sphalerite is found. The gangue minerals are kaolin (clay), quartz, limonite, chlorite, amphibole, pyroxene, and garnet, the silicate minerals replacing original limestone, and the ores containing practically no lime. The ores mined are of three kinds—oxidised ores, sulphide ores, and a low-grade ore containing much clay. These are mixed in such proportion as to form, with the addition of some limestone, a mixture that can be smelted direct in blast-furnaces, with the production of a 40 per cent copper-iron matte, which is converted to metallic copper by being bessemerised in converters.

Copper and Iron Sulphide Minerals Disseminated throughout Eruptive or Metamorphic Rocks.

Bingham, Utah.—The ore consists of porphyry (monzonite), through which are disseminated small grains of pyrite, chalcopyrite, bornite, and chalcocite. The gangue rock, altered monzonite, is composed of the following minerals, stated in the order of the quantity present:—Quartz; the felspars, orthoclase, and plagioclase, partly altered to sericite; hornblende, and biotite. An average analysis of the ore is about as follows;—Silica, 66·55 per cent; alumina, 16·75 per cent; iron, 2·44 per cent; lime, 1·27 per cent; soda and potassa, 7·60 per cent; sulphur, 1·54 per cent; copper, 1·52 per cent; remainder, chiefly oxygen, carbonic acid, and water, 1·28 per cent. The copper content of the ore varies between 1·4 and 2 per cent. The combined gold and silver content is valued at about 25 cents or less per ton. The ore is concentrated at about 18 to 1; that is, 18 tons of ore make 1 ton of concentrate, the recovery of copper by concentration being about 66·5 per cent. An average analysis of concentrate is :—Gold, 0·154 ounce; silver, 1·80 ounces; copper, 24·1 per cent; silica, 16·8 per cent;

* *Technical Paper 143, Department of the Interior, U.S.A. Bureau of Mines.*

iron and manganese, 22·2 per cent; sulphur, 32·1 per cent; alumina, 1·70 per cent.

Ely, Nev.—The Nevada ore occurrence at Ely is similar to that at Bingham, Utah. The contents of the ore in metal are:—Copper, 1·70 per cent to 2 per cent; silver and gold, about 45 cents per ton. About 68 per cent of the copper and 50 per cent of the gold and silver is recovered by the combined operations of concentration and smelting. The ore is concentrated 9·1 into 1, and the concentrate contains about 10·5 per cent copper.

Santa Rita, N. Mex.—The Santa Rita ore consists of an altered quartz diorite—a rock resembling monzonite, except that the felspar present is chiefly a plagioclase—through which are disseminated pyrite, copper sulphide minerals, malachite, azurite, and native copper. The ore differs from the Ely and Bingham ores in the nature of the gangue rock and in the presence of a greater variety of copper minerals. The ore contains about 2 per cent copper, and is concentrated into a 27 per cent copper product, which is shipped to a smelter at El Paso, Tex.

Near Globe, Ariz.—The ore consists of mineralised schist (a metamorphic rock) and porphyry. The copper minerals disseminated through the rock are chiefly cupriferous pyrite and chalcocite. The copper content worked by one set of mines is about 2·2 per cent, and the ore is concentrated as previously described. An analysis of the concentrate follows:—Gold, none; silver, 0·446 ounce; copper, 18·55 per cent; silica, 24·2 per cent; iron and manganese, 22·7 per cent; lime, 0·6 per cent; sulphur, 25·4 per cent; alumina, 3·6 per cent.

In ore bodies worked by other mines the copper content ranges from 2 to 2·5 per cent. About 20 to 22 tons of ore are concentrated into 1 ton of concentrate containing about 40 per cent copper. The extraction by concentration is about 75 per cent.

The "disseminated" ores or "porphyry copper" ores are a development of recent years, and are already a source of much copper. Taken as a whole, these mines have estimated ore reserves enough to produce 5,705,000 tons of copper, which with the present milling capacity can be recovered in 25·5 years, or at the rate of 223,710 tons of copper yearly. The total production of copper in the United States for 1914 was 782,854 tons, the production of the porphyry mines being 160,979 tons, or 20·5 per cent.

Ores containing Lead and Copper and Usually some Gold and Silver.

Silverton, Colo.—The Silverton ore bodies are veins in eruptive rock. The ore consists of the gangue minerals, quartz, rhodochrosite, barite, and calcite, and the ore minerals, pyrite, chalcopyrite, galena, tetrahedrite, bornite, sphalerite, stibnite, and sometimes native gold. Two classes of ore are mined:—(1) High-grade ore, smelted direct, and (2) concentrating ore, which is concentrated about 4½ into 1, and the concentrate smelted. The high-grade ore is divided into two kinds:—(*a*) So-called "lead" ore, of which the following is a typical analysis: Gold, 0·18 ounce, and silver, 48 ounces per ton; lead, 38 per cent; and copper, 4·15 per cent; and (*b*) so-called "copper" ores, containing, for example, gold, 1·33 ounces, and silver, 68·1 ounces per ton; lead, 11 per cent; and copper, 8·3 per cent. The concentrate contains 0·5 ounce to 1·5 ounces of gold, and 20 to 30 ounces of silver per ton, and lead 20 per cent, and copper [illegible] per cent. The ores from the different mines vary much in value, concentrating ore containing gold, silver, lead, and copper worth 8 to 20 dols. per ton. High-grade ores and concentrates are treated by lead smelting.

Park City, Utah.—The Park City ore consists of a quartzite and limestone gangue in which are the following ore minerals:—Galena, sphalerite, pyrite, chalcopyrite, and tetrahedrite. About one-third to one-half of the ore is smelted direct; the remainder is concentrated. A typical analysis of high-grade ore is as follows:—Gold, [illegible]046 ounce, and silver, 55·7 ounces per ton; lead, [illegible] per cent; copper, 2·2 per cent; silica, 31·7 per cent; iron and manganese, 6 per cent; lime, 0·5 per cent; zinc, 14·2 per cent; sulphur, 11·8 per cent. The concentrate from the low-grade ore does not contain much copper, and has the following typical analysis:—Gold, 0·032 ounce, and silver, 34·5 ounces per ton; lead, 33·5 per cent; copper, 0·9 per cent; silica, 10·4 per cent; iron and manganese, 13·20 per cent; lime, 0·8 per cent; zinc, 12·5 per cent; sulphur, 36·0 per cent. Copper-lead ores of similar character are shipped from the Bingham district, Utah, the Cœur d'Alenes, Idaho, and from Georgetown and Silver Plume, Clear Creek County, Colo. Typical analyses of Clear Creek County lead-copper ores are given in Table I.

TABLE I.—*Typical Analyses of Clear Creek County, Colo., Lead-copper Ores.*

	Analysis No. 1.	Analysis No. 2.
Gold (ounces)	1·91	0·99
Silver (ounces)	12·6	26·7
Lead (per cent)	28·7	19·4
Copper (per cent)	2·8	2·3
Silica (per cent)	30·5	30·9
Iron and manganese (per cent)	10·00	10·00
Lime (per cent)	—	—
Zinc (per cent)	3·8	8·8
Sulphur (per cent)	14·0	17·9

Lead Ores (commercially free from the precious metals).

South-Eastern Missouri.—The ore is a dolomitic limestone (lime-magnesia carbonate), through which is disseminated galena and a little pyrite. An average analysis of the ore is:—Lead, 5·90 per cent; copper, 0·065 per cent; zinc, 0·82 per cent; sulphur, 2·18 per cent; silica, 4·565 per cent; iron, 3·925 per cent; manganese, 0·465 per cent; lime, 25·30 per cent; magnesia, 14·50 per cent; alumina, 5·75 per cent; carbon dioxide, 36·02 per cent; silver, 0·13 ounce per ton. The ore is concentrated about 12 into 1, and the concentrate smelted. An average analysis of concentrate is:—Lead, 63·67 per cent; copper, 0·45 per cent; zinc, 1·70 per cent; sulphur, 13·35 per cent; silica, 0·64 per cent; iron, 3·16 per cent; manganese, 0·33 per cent; lime, 4·98 per cent; magnesia, 2·93 per cent; alumina, 1·29 per cent; carbon dioxide, 7·05 per cent; silver, 1·02 ounces per ton.

Lead Ores Containing Precious Metals.

Many lead ores containing precious metals also contain zinc in considerable quantity, but in the ores under this class it is not saved.

Leadville, Colo., Ores.—Leadville (Colo.) ores may be divided into five classes as follows:—(1) Oxidised silver-lead ores; (2) sulphide silver-lead ores, containing less than about 10 per cent zinc; (3) sulphide silver-lead ores, containing more than 10 per cent zinc; (4) iron sulphide-copper sulphide ores, containing silver and some zinc; (5) other ores not included in the foregoing classes, such as oxides of iron and manganese containing silver, iron sulphide-gold ores, and zinc ores. Class 4 has been mentioned under copper ores. The discussion following covers only classes 1 and 2.

Oxidised Silver-lead Ores.—Oxidised silver-lead ores, formerly of great importance in the United States, are now nearing exhaustion. They represent the ore bodies derived from the oxidation of sulphides. The ores consist of cerussite, some anglesite, and a little unaltered galena, in a gangue of hematite, limonite, and manganese oxides, with occasionally some barite. The silver occurs chiefly as cerargyrite. Typical ore from Fryer Hill, Colo., had the following analysis:—30 to 35 per cent iron and manganese, as oxides; silica, 12 to 15 per cent; lead, 21·45 per cent; silver, 65·42 ounces per ton; remainder oxygen, carbonic acid, and water. These ores were smelted to lead-silver bullion in blast-furnaces.

Sulphide Ores.—The sulphide ores consists of a mixture of silver-bearing galena, sphalerite, and pyrite in a gangue

of dolomitic limestone and an eruptive rock (felsite). The amount of gangue rock in the ore is usually small. The amount of sphalerite varies much. Ores containing less than 10 per cent zinc are treated direct by the lead smelter; those with more than this may be subjected to ore-dressing operations which yield a galena concentrate low in zinc, and a pyrite-sphalerite concentrate low in lead, this latter going to the zinc smelter after a magnetic separation of sphalerite from pyrite. Sulphide ores going direct to the lead smelter have a composition about as follows:—Lead, 44 to 45 per cent; zinc, 13 to 12 per cent; iron, 11 to 9·50 per cent; sulphur, 25 to 30 per cent; insoluble residue, chiefly silica, 1 to 2 per cent; silver, 10 to 15 ounces per ton. These ores are roasted, and the "sinter" or roasted product is smelted in blast-furnaces to lead bullion.

Ore Classification Based on Lead Content.—Table II. is a classification of ores from the lead smelter's point of view, and is based mainly on Leadville, Colo., ores, but is widely used in the West for ores in general.

TABLE II.

Designation.	Lead. Per cent.	Iron. Per cent.	Insoluble. Per cent.	Sulphur. Per cent.
Oxides and Carbonates.				
Oxides—				
Iron oxide ores ..	<5	45 to 60	2·5 to 17	<1
Siliceous dry oxide	<5	6 to 45	17 to 84	<3
Siliceous lead oxide	5 to 20	5 to 30	30 to 55	<3
Carbonates—				
Dry carbonates ..	<5	30 to 48	20 to 35	3
Lead carbonate ..	>5	19 to 46	7 to 30	0 5
Sulphides.				
Dry sulphides—				
Siliceous, dry ..	<5	Up to 15	>50	>3
Iron, dry	<5	15 to 30	<50	>3
Iron	<5	>30	<30	High
Lead sulphides—				
Siliceous	>5	<30	15 to 50	12 to 20
Iron	5 to 15	>30	<15	13 to 35
High	>30	5 to 20	1·5 to 5	Up to 26

(All may contain copper and zinc).

Remarks on Classification.—The gold and silver content of the ores may vary widely, from practically no gold or silver to a very high content in these metals. The *limiting values of the constituents named are approximate* only, and the classification cannot be considered rigid. Thus under dry sulphides are understood to be included sulphide ores that contain less than 5 per cent lead, and in which the sulphide mineral is chiefly iron sulphide.

A sulphide ore from the lead smelter's point of view is one that necessitates roasting as a preliminary operation to smelting. This implies a sulphur content of more than 3 per cent. The dry sulphides may range from mineral mixtures in which the siliceous gangue minerals predominate, and the iron sulphides are subordinate in amount to almost pure iron sulphide. Hence the classification siliceous dry sulphide, iron dry sulphide, and iron sulphide. The first contains only a small amount of sulphide mineral, the second a considerable amount, and the third consists almost entirely of sulphide mineral. Naturally the classes grade into each other, and rigid limits for each class cannot be set.

Copper may be present in all of the ores mentioned in the classification. Usually the amount of copper is small, but a content as high as 5 or 6 per cent is not uncommon in the so-called lead-copper ores or in the dry sulphides.

The term "dry" applies to ores that contain less than 5 per cent lead. More broadly speaking, the term "dry" should apply to any ore that has insufficient lead or copper to act as a collecting agent for its gold and silver content during smelting, but the lead smelter usually confines the term to ores containing less than 5 per cent lead, with no particular reference to the copper content.

Composition of Typical Ores Classified on Basis of Lead Content.—Table III. gives the composition of typical ores classified on the basis of lead content.

(To be continued).

INSTITUTE OF CHEMISTRY OF GREAT BRITAIN AND IRELAND.

REPORT ON PROPOSALS SUBMITTED BY THE EXECUTIVE COMMITTEE OF THE PROPOSED BRITISH ASSOCIATION OF CHEMISTS.

I. THE Council of the Institute of Chemistry have considered the proposals submitted to them, on December 14, 1917, by the Executive Committee of the proposed British Association of Chemists.

II. The proposals were as follows:—

(A). That the Institute of Chemistry should become the sole registration authority for chemists—an authority bearing no relation whatever to the granting of the diplomas A.I.C. and F.I.C.—with a view to the Institute carrying out the objects of the proposed British Association of Chemists as outlined in the circular calling the meeting held at Manchester on November 10, 1917. (See III. below).

(B). If the *Institute cannot see its way to modify its* constitution to carry out the first proposition, that it should adopt as a minimum qualification for A.I.C. the (*a*) and (*b*) qualifications (see IV., below) of the proposed British Association of Chemists and adopt the objects outlined in the circular convening the meeting held on November 10, 1917;
Provided that after 1921 only persons qualified under (*a*) of the British Association of Chemists qualifications be eligible for A.I.C.

(C). That Local Sections shall be formed and that the Council shall consist largely of representatives from such Sections.

(D). That should the Institute decide on having a separate registration body, the latter should be self-governed and should carry out the objects of the proposed British Association of Chemists.

III. The objects referred to are (*a*) to (*d*) following:—

(*a*) To obtain power to act as sole registration authority for all Chemists.

(*b*) To have the word Chemist legally re-defined.

(*c*) To safeguard the public by obtaining legislation ensuring that certain prescribed chemical operations be under the direct control of a Chemist.

(*d*) To raise the profession of the Chemist to its proper position among the other learned Professions, so that it may attract the attention of a larger proportion of the best intellects, and thereby secure a supply of highly-trained Chemists adequate to the industrial needs of the country.

IV. The qualifications (*a*) and (*b*) referred to (in II., above) are as follows:—

(*a*) Any person holding a University degree, with first or second class honours in chemistry, or its equivalent in the opinion of the Council;

(*b*) Any person who can show evidence satisfactory to the Council of having had a sufficient general and scientific education and of having practised pure and applied chemistry for not less than seven years, and who holds a responsible position. (This clause to apply only up to December 31, 1921).

V. The Council find on consideration that the objects of the Association are practically included in the aims and objects of the Institute. They, therefore, deprecate the

formation of another body of Chemists for carrying out those objects.

VI. The Council do not deem it advisable to adopt proposal (A). (See II., above).

VII. The Council are prepared to submit to the Fellows and Associates of the Institute in Extraordinary General Meeting the following modifications of the regulations and constitution of the Institute with a view to meeting proposal B, so far as the Council deem it advisable to do so—

1. That the Council modify the existing regulations of the Institute in order to include as many chemists as possible in the Membership (Associateship and Fellowship) of the Institute, *so far as such a course is compatible with the provisions of the present Charter.*
2. That any Candidate who has complied with the following conditions be accepted as eligible to apply for admission to the Associateship of the Institute—

   (*a*) That he has attained the age of twenty-one years; and either

   That he has obtained a degree with first or second class honours in Chemistry (or other degree or diploma recognised by the Council as equivalent) after a three years' systematic day course, and (i.) has taken a further years' training in Chemistry at a recognised University or College; or (ii.) has had two other years' approved experience (see Note 1) under a Fellow of the Institute, or in a laboratory or works approved by the Council; or

   That he has obtained a degree with first or second class honours in Chemistry (or other degree or diploma recognised by the Council as equivalent) after a four years' systematic day course;

   Provided in every case that the Candidate has produced satisfactory evidence of training in Physics, Mathematics, and an optional subject.

   (*b*) That until December 31, 1921, Candidates of twenty-seven years of age and upwards who have complied with the conditions prescribed in qualification (*b*) (see IV., above) submitted by the representatives of the proposed British Association of Chemists should be accepted as eligible for admission as Associates of the Institute, provided that they have complied with the provisions of the Charter of the Institute with regard to general education, scientific training (in Chemistry, Physics, and Mathematics), and the passing of class examinations held in connection with such training (see Note 2).

   (*c*) That Candidates who have not complied with the conditions specified in (*a*) or (*b*) immediately above or with the regulations adopted as a temporary (War) measure, be required to comply with the regulations adopted by the Council in July, 1917.
3. That the standard of qualification for the Fellowship of the Institute should be maintained at a decidedly higher level than that for the Associateship.
4. That the list of Institutions recognised by the Council for the training of Chemists should be reconsidered with a view to its further extension.
5. (*a*) That with regard to proposal C (see II., above), local branches of the Institute be formed in important centres where a Membership of not less than, say, forty can be assured.

   (*b*) That the main objects of such branches should be to maintain the interest of the Members in the general welfare of their profession and to promote social intercourse.
6. That steps be taken to revise the present system for the election of the Council, in order to give the general body of Members greater freedom of nomination.

NOTE 1.—One year may be accepted by the Council as sufficient where the approved experience in a laboratory or works has been acquired subsequently to the prescribed training in a recognised University or College.

NOTE 2.—In considering applications under this clause the Council will expect Candidates to produce evidence of having been trained and occupied in a manner which in the opinion of the Council is equivalent to fulfilling the conditions required of Candidates admitted under *a*.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, January 24, 1918.

Sir J. J. THOMSON, O.M., President, in the Chair.

PAPERS were read as follows:—

"*Graphical Solution for High Angle Fire.*" By Prof. A. N. WHITEHEAD, F.R.S.

"*On Flocculation.*" By SPENCER PICKERING, F.R.S.

The subsidence of suspended matter on the addition of a flocculant to a mixture of kaolin and water is accompanied by an increase of 100 to 200 per cent in the specific volume of the sediment deposited. This increase, as well as the disappearance of Brownian motion, proves that flocculation is due to an increase in the size of the particles. With acids as flocculants, definite combination between them and the kaolin occurs, the acid being almost completely removed from the solution up to the point when flocculation is complete, beyond which no more is removed. The acids being in a highly hydrated condition accounts for the increase in volume of the kaolin particles on uniting with them. With alkalis the phenomena are the same, but combination is complete only in the presence of excess of alkali; hence the concentration at which flocculation occurs is much higher. In very weak alkaline solutions where there is but little actual combination the subsidence of the particles is retarded by the attraction of the alkali present.

The specific volumes of the sediment show that the interaction between the flocculant and the kaolin extends beyond the point at which flocculation is complete, the subsequent changes being due to the dehydrating action of the flocculant and the combination of the partially dehydrated kaolin with the concentrated flocculant. The freezing of kaolin suspensions or of hydrated precipitates produces contraction of the sediment, and this has been proved to be due to dehydration and to be non-reversible.

"*Revolving Fluid in the Atmosphere.*" By J. AITKEN, F.R.S.

The paper deals with the objections to the cyclonic theory of circulation recently advanced by Sir Napier Shaw. These objections are founded on the fact that the charts of isobars and winds of the weather maps nowhere show a circulation such as would be given by a combination of the motions of rotation and translation. It is pointed out that these objections are based on suppositions which do not find support in nature. If the cyclone were a closed system the winds would be such as Sir Napier says they ought to be, but as the cyclone is an open one and draws in air at its lower end, and as this incoming air is only on its way to become part of the system it cannot be treated as having the revolution and translation of the cyclone. If the combination of these two motions is to be found anywhere it will probably be in the higher winds, and even there they will be affected by the general circulation in the system. It is pointed out that the statement frequently made that eddies and small tropical revolving storms have their analogue in the vortex-ring is a mistaken one because the vortex-ring is a dying system from the moment of its birth, while revolving storms, small and

great, can take in energy and grow. It is shown that the diameter of cyclones is greatly influenced by their barometric gradients, and it is suggested that the mechanical effects of rainfall may be the initiating cause of secondary cyclones.

"*Ultra-violet Transparency of the Lower Atmosphere and its Relative Poverty in Ozone.*" By Hon. R. J. Strutt, F.R.S.

1. The lower atmosphere is found to be comparatively transparent to ultra-violet light. The λ 2536 can be detected on the spectrum of a mercury lamp four miles distant.

2. The solar spectrum, even when observed from high altitudes when the equivalent thickness of air overhead (reduced to N.T.P.) is less than four miles, is limited by atmospheric absorption to λ 2922. Air near the ground level is therefore much more transparent to ultra-violet light than the upper air.

3. Since the limitation of the solar spectrum is almost certainly due to ozone it follows that there must be much more ozone in the upper air than in the lower.

4. Scattering by small particles acts in the same way as ozone to absorb ultra-violet radiation from a distant source, and this action makes quantitative estimation difficult. Even if the observed enfeeblement of λ 2536 were entirely due to ozone, 0·27 mm. of pure ozone in four miles of air would suffice to produce it. Taking scattering into account the quantity is probably much less, and these is no evidence from this investigation that any ozone is present in the lower air.

"*Presence in the Solar Spectrum of the Water-vapour Band* λ 3064. By Prof. A. Fowler, F.R.S.

It is shown in this paper that the band at λ 3064 which is usually attributed to water-vapour is quite strongly represented in the solar spectrum, and accounts for at least 150 lines which were previously unidentified.

"*The Ultra-violet Band of Ammonia and its Occurrence in the Solar Spectrum.*" By Prof. A. Fowler, F.R.S., and C. C. L. Gregory.

The ammonia band having its greatest intensity at λ 3360 has been photographed with high resolving power, and the positions of 260 component lines have been determined. In the principal maximum, and in a secondary maximum at λ 3371, the band lines are very closely crowded and form series of the usual type. On the less refrangible side the principal lines form three series which coalesce and fade out at λ 3450, and there is a similar set of three series on the more refrangible side which coalesce and disappear at λ 3287. These two groups however are not symmetrical, and they differ considerably from the more usual type of series. It is shown that the ammonia band lines are consistently represented in the solar spectrum, and account for about 140 faint lines which were previously unidentified. The remaining band lines are either too weak to appear in the sun or are obscured by lines of metallic origin. The brightest part of the ammonia band accounts for the greater part of Group P of the solar spectrum.

CHEMICAL SOCIETY.

Ordinary Meeting, January 17, 1918.

Prof. W. J. Pope, C.B.E., F.R.S., President, in the Chair.

The President referred to the loss sustained by the Society, through death, of the following Fellows:—Charles Bradshaw and Reginald C. Woodcook.

Messrs. H. J. Cunningham, W. A. Dickie, F. Bridge, and O. A. Le Beau were formally admitted Fellows of the Society.

Certificates were read for the first time in favour of Ernest Atkinson, 5, Bank Road, Workington; Albert Leslie Bloomfield, B.A., Rose Cottage, Epping New Road, Buckhurst Hill; Joseph William Christelow, B.Sc., Highcliff View, Guisborough; Thomas Gifford Elliot, Hillcote, Park Edge, Hathersage, Sheffield; Frederick Page Evans, B.Sc., 8, Vicarage Road, Frindsbury, Rochester; Cecil Stevenson Garnett, 12, Cross Street, Chesterfield; Frederick Horace Garner, M.Sc., 172, St. Paul's Road, Balsall Heath, Birmingham; Francis Clint Guthrie, B.A., The Roscote, Heswall, Cheshire; Alan Haythornthwaite, B.Sc., 79, Clapham Common, West Side, S.W. 4; William Earl Hughes, B.A., 6, Coleherne Terrace, Earl's Court, S.W. 5; Herbert Spencer Kipling, West End House, Victoria Road, Stechford, Birmingham; Francis Charles Lewis, B.Sc., Nwch-y-don, Elkington Road, Burry Port, Carm.; William Jackson Lund, M.Sc., "Fenryn," Temple Road, Stowmarket; Archibald Bruce Macallum, 243, College Street, Toronto; Alfred Bertram Mann 85, Laburnum Avenue, Garden Village, Hull; Tudor Williams Price, B.A., M.Sc., "Gowanlea," Caledonia Road, Saltcoats; Robert Ray, B.Sc., Eastriggs, Dumfriesshire; Ferdinand Roques, 36, Rue Ste. Croix de la Bretonnerie, Paris; Alfred Ulrich Max Schlaepfer, 12 Arlington Gardens, Chiswick; William Leonard Scotcher, Eastriggs, Dumfriesshire; Harold Pethick Shilston, 49, Radnor Drive, Wallasey, Cheshire; George Taylor, 32, Sothsby Road, Highbury, N. 5; John Trotter, M.A., D.Sc., c/o Mactaggart, 12, Meadow Place, Edinburgh; Arthur William Willis, 30, Manor Road, Stechford, Birmingham; Charles Edmund Wood, M.Sc., 83, Kingswood Road, Moseley, Birmingham.

CORRESPONDENCE.

PERCO LIFE-SAVING GOODS.

To the Editor of the Chemical News.

Sir,—I beg to take this opportunity of pointing out the realiability of Perco life-saving goods. Perco is a commodity possessed of peculiar qualities and virtues, being lighter than cotton, softer than wool, and warmer than fur.

Its great buoyancy powers render it invaluable for life-saving purposes, and the greatest attraction that should appeal to people at home nowadays is the fact that it is a trade which is being captured from Germany. That it is assured of a big future is positive, and you will readily perceive that it has come to stay, and we hope to be developed in England as a great, and possibly, owing to its adaptability, even a national industry.

We are contractors to the Royal National Lifeboat Institution. - We are, &c.,

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RECRUITMENT OF CHEMISTS FOR THE ARMY.

To the Editor of the Chemical News.

Sir,—I should be very much indebted if one of the readers of the Chemical News could give me some information regarding the recruitment of chemists for the Army.

I am twenty-one years of age, and have had nearly seven years works laboratory experience in iron and steel and metallurgical analysis, including two and a-half by-products and coal-tar distillation. I hold the following technical honours:—Board of Education Examinations in Chemistry (Higher) and Metallurgy (Higher); also City of London Guilds Honours and Silver Metal in Iron and Steel. I have the position of teacher in metallography at a technical institute also.

Being under twenty-three years of age I am accordingly to be recruited for the Army, as per the Protected Occupa-

tion List just issued. I am quite willing to do my bit, but am sure that with my experience I am more service in industry. I should like an opinion if any special provision is made for such cases.

I think myself that after so many years of hard work to attain some merit, my services could be better utilised than with the rank and file of infantry regiments.

If industrial positions are not available are there any special units I could join to make my training suitable as recruit? I should be very much indebted for any such particulars and advice regarding special chemists units, &c. (commissions, &c.).

I have a friend who is situated very similar to myself, and I ask also on his behalf. We are both certified "A" class, and are at present in controlled establishments, holding each a Red Protection card.—I am, &c.,

BERNAL A. BECKLEY.

20, Market Street, Wolverhampton.

MISCELLANEOUS.

Chemical Society.—At the Ordinary Scientific Meeting on February 21, at 8 p.m., Prof. the Hon. R. J. Strutt, M.A., Sc.D., F.R.S., will deliver a lecture entitled "Recent Studies on Active Nitrogen."

Royal Institution.—A General Meeting of the Members of the Royal Institution was held on the 4th inst., Sir James Crichton-Browne, J.P., F.R.S., Treasurer, in the Chair. J. Turner MacGregor-Morris and Prof. Paul Popovic were elected Members. The Secretary announced the decease of Sir John Wolfe Barry, Member of the Royal Institution, and a resolution of condolence with the relatives was passed. The Managers reported that Dr. Mond, under the Conveyance and Deed of Trust of the Davy-Faraday Research Laboratory of the Royal Institution, covenanted to pay to the Royal Institution before the year 1926, the sum of £62,000 as Endowment Fund. The Trustees have in the most generous way anticipated the obligation by eight years, and have transferred the sum of £66,500 in 5 per cent War Stock to the Trustees, nominated by the Managers, of the Davy-Faraday Research Laboratory Endowment Fund. This will add materially to the income available for the purpose of promoting and maintaining the efficiency of the Davy-Faraday Research Laboratory, in the Advancement of Original Research in Chemical and Physical Science.

MEETINGS FOR THE WEEK.

MONDAY, 11th.—Biochemical Society, 5.30. (In the Botany Buildings, Imperial College of Science and Technology, South Kensington).

TUESDAY, 12th.—Royal Institution, 3. "Problems of British Anthropology," by Prof. Arthur Keith.

WEDNESDAY, 13th.—Royal Society of Arts, 4.30. "The Relations between Capital and Labour — Reasonable Hours, Co-partnership, and Efficiency," by Lord Leverhulme.

THURSDAY, 14th.—Royal Institution, 3. "Three French Moralists and their Influence on the War—La Rochefoucauld," by Edmund Gosse, C.B.

— Royal Society of Arts, 4.30. "The Hide Trade and Tanning Industry of India," by Sir Henry Ledgard.

— Royal Society. "Artificial Production of Echinoderm Larvæ with Two Water-vascular Systems, and also of Larvæ devoid of a Water-vascular System," by E. W. MacBride. "Quantitative Differences in the Water-conductivity of the Wood in Trees and Shrubs," by J. B. Farmer. "Efficiency of Muscular Work," by Capt. M. Greenwood.

FRIDAY, 15th.—Royal Institution, 5.30. "The Mechanism of the Heart," by Prof. E. H. Starling.

SATURDAY, 16th.—Royal Institution, 3. "Problems in Atomic Structure," by Sir J. J. Thomson.

TO comply with Regulation 8 (b) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Analytical Chemists required. Male, ineligible for Military service, or Female. No person resident more than ten miles from advertiser's works or already engaged on Government work need apply.—Apply, Stobie Steel Company, Dunston-on-Tyne.

Engineering Works in London have a vacancy for an Assistant Chemist in their Testing Laboratory. Applicant must be ineligible for the Army, or a Lady. Give particulars of age, training, and salary required.—Address, G., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

First-class Cement Chemist for India wanted. Must have had at least five years' practical experience, be physically fit, resourceful, energetic; unmarried preferred.—Write, "Indian Cement," care of Street's, 30, Cornhill, London, E.C. 3.

LABORATORY.—A Youth of 16, with good knowledge of Chemistry, desires Appointment in established Laboratory as Assistant. London preferred.—Address, A. H., 33, Priory Road, Kew, S.W.

Wanted in Government Factory, Metallurgical Chemist able to control Pyrometers, including standardisation and upkeep, with thorough knowledge of Photomicrography of Steel and Non-ferrous Alloys and general routine of Metallurgy. No person already engaged on Government work need apply.—Call your nearest Employment Exchange and quote No. A 4533.

Wanted, good Second-hand BALANCES. Urgently required for Chemical Laboratory.—Particulars to Crittall Manufacturing Co., Braintree, Essex.

Wanted, "Chemical News," 1863, 1864, 1869, 1892, 1895 to 1914 or part; General Index vols. 1—100; "Chemical Gazette," vol. 17 (1859); "Journ. Soc. Dyers and Colourists"; "Journ. Soc. Chem. Ind."; "Quarterly Journ. Chem. Soc."—Offers to "C. 186," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, "MEMORIALS OF THE GOODWIN SANDS," by Mr. Gattie.—Address, W. S., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

COUNTY BOROUGH OF STOKE-ON-TRENT.

CENTRAL SCHOOL OF SCIENCE AND TECHNOLOGY.

POTTERY DEPARTMENT.

The Governors of the above School invite applications for the Post of CHIEF ASSISTANT to the Principal (Dr. MELLOR) of the POTTERY DEPARTMENT.

The person appointed must be a fully-qualified Physical Chemist with a high University Degree. He will be required to work in the School under the direction of Dr. Mellor, and acquaint himself with the manufacturing conditions of the industry; but in the first instance he will not be expected to possess a technical knowledge of the Pottery industry. Commencing salary £400 per annum. In the event of a candidate proving himself suitable, there will be prospects of a successful career.

Forms of Application (to be returned not later than the 25th day of FEBRUARY, 1918) will be forwarded on receipt of stamped addressed foolscap envelope to Dr. W. LUDFORD FREEMAN, Clerk to the Governors, Town Hall, Hanley, Stoke-on-Trent.

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'HE CHEMICAL NEWS

VOL. CXVII., No. 3038.

THE

INFLUENCE OF CARBON MONOXIDE ON THE 'ELOCITY OF CATALYTIC HYDROGENATION.*

By EDWARD BRADFORD MAXTED, Ph.D., B.Sc.

VHILE the inhibitive action of carbon monoxide on atalytic hydrogenation is well recognised, comparatively ttle has been published with regard to the quantitative ide of the phenomenon.

It is therefore proposed to give in the present paper a hort account of the principal results obtained by the author studying the effect of this impurity on the velocity of bsorption of hydrogen by an unsaturated organic body in he presence of nickel.

The subject possesses a particular interest by reason of he fact that hydrogen prepared commercially from water-as contains as a general rule a small percentage of carbon monoxide, and, indeed, the present work on the harmful ffects of carbon monoxide content has been carried out connection with an investigation of the possibility of reparing directly from water-gas hydrogen free from arbon monoxide.

Reference may perhaps be made to a recent paper by A. Hofmann and H. Schibsted (*Ber.*, 1916, xlix., 1663) n the retardation by carbon monoxide of the oxidation of ydrogen by chlorate solutions containing osmium oxide s a catalyst. The results, although obtained for a reaction f a different nature from that which is the subject of the resent paper, are of considerable interest in connection vith catalytic poisoning by carbon monoxide generally.

The following results relate to the hydrogenation of live oil by means of hydrogen containing various small uantities of carbon monoxide, olive oil being chosen for theoretical reasons on account of its approximation to the glyceride of oleic acid. The results obtained emphasise the entire unsuitability for catalytic work of hydrogen containing even as small a proportion of carbon monoxide as one quarter per cent.

The apparatus by means of which the measurements were made is one which has been found very useful for the quantitative study of catalytic hydrogenation generally, and is therefore described in detail. It consists of a measuring burette A, containing hydrogen, and connected as shown to a second gas burette B. C is a drying tube containing calcium chloride and connecting A to the hydrogenation vessel M, which contains olive oil and catalyst. The hydrogenation vessel is shaken in an oil bath O by means of a shaker S. D is a three-way tap by means of which the apparatus is filled with hydrogen.

In order to ensure uniformity a considerable quantity of purest olive oil was refined by treatment with sufficient soda to neutralise its free fatty acids, the soap formed thereby being removed by washing with water. The pure neutral oil thus obtained was stored in a large bottle and was found to give identical results with standard pure hydrogen both at the beginning and at the completion of the series of experiments.

The hydrogen mixtures were made up artificially from purest electrolytic hydrogen and carbon monoxide. The carbon monoxide was prepared by the action of sulphuric acid on sodium formate, followed by absorption of any traces of CO_2 or SO_2 by means of soda lime, and contained usually about 2 per cent of hydrogen.

In general the pure hydrogen was contained in a glass gas holder over boiled water, and to it added from a burette the quantity of carbon monoxide requisite to make up the mixture desired.

The method of making each measurement was as follows:—

Into the hydrogenation vessel M, disconnected for this purpose from its rubber connection, stock nickel catalyst containing 0·1 grm. nickel was introduced, followed by 10 grms. of the stock olive oil. M was then reconnected and the whole apparatus filled with the hydrogen to be tested. This was done by connecting the two branches of D to a Geryk pump and to the hydrogen gas holder respectively,

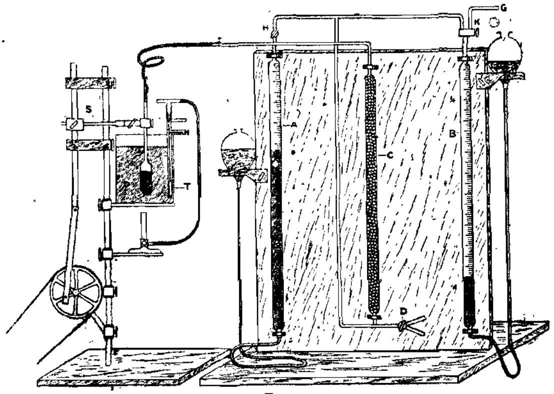

FIG. 1.

* A Paper communicated to the Transactions of the Faraday Society.

and by turning the tap at D, alternately evacuating the system and filling it with hydrogen. The oil and catalyst in M were found to give off considerable quantities of gas under the influence of the vacuum, and, in order to avoid excessive frothing, the first few evacuations were carried out with M out of the oil bath and consequently cold. As soon as the violence of the ebullition on evacuating had somewhat subsided, M was heated by being immersed for a short time in the oil bath O, this being previously heated to 180° C. and maintained at this temperature by means of

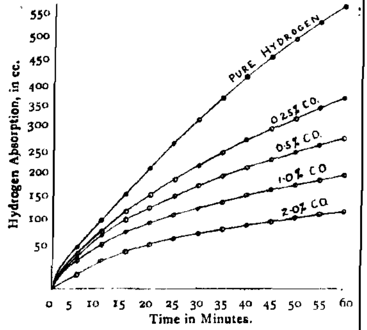

FIG. 2.

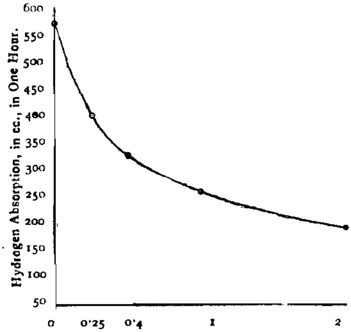

FIG. 3.

the thermostat T. The system was again cautiously evacuated and filled several times. After the final filling the taps at H and K were opened for a moment in order to allow hydrogen to flow into A and B in sufficient quantity to fill these about two-thirds. D was now closed, H opened, and the hydrogen supply transferred from D to G, K being kept shut. Finally, M was adjusted at such a depth in the oil bath that it could be shaken without undue splashing, and the volumes of gas in A and B were read off.

With the arrangement of three-way taps shown, there is no possibility of hydrogen entering the system A C M directly by inadvertently turning the tap in the wrong direction in the course of the experiment.

The shaking was carried out at a constant rate of 480 double strokes per minute, this high speed being chosen in preference to a lower one since it was noted that the higher the rate of shaking the less the influence of small percentage changes in the speed of the driving motor or of small variations in the degree of belt slip. The speed of shaking was, however, carefully checked from time to time in the course of each experiment, and the regular curves obtained bear witness to the constancy of this and other conditions.

The experiment was in every case started by switching on the current to the shaker simultaneously with starting the timing watch, and it was observed that the absorption obtained during the first few minutes was as a rule less than that required by the complete curve. This preliminary period is probably caused by the necessary preliminary penetration of the hydrogen to the nickel/oil surfaces which form the seat of the reaction.

The absorption of hydrogen by the oil in M is followed by the movement of the water in A. As soon as the hydrogen in A is almost exhausted, the tap K is turned, S is

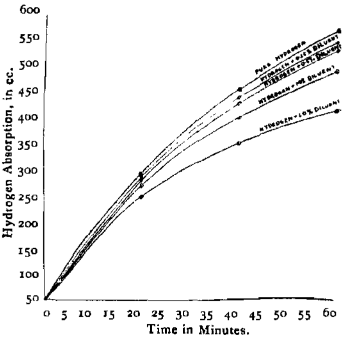

FIG. 4.

raised, and the gas in B allowed to flow completely into the closed system M C A, the volume of this addition being noted. B is refilled with hydrogen from G, this volume being added to the shaking system as and when required by the hydrogen absorption. The shaker is, of course, run continuously, and the hydrogen absorption read off from A at suitable intervals of time, taking into consideration the volume added from B.

Working in this way the series of results shown in Table I. was obtained, the temperature being in every case 180° C., the quantity of oil 10 grms., and the nickel content of this 0·1 grm.

The measurements were in each case taken for a run of one hour, this period being, in the case of pure hydrogen, sufficient for the introduction of approximately three-quarters of the hydrogen required for complete saturation.

These results are shown graphically in Fig. 2. From the very considerable depression of the original curve produced by the presence of even 0·25 per cent of CO in the hydrogen it will be seen that, if hydrogen containing carbon monoxide is to be used for the hydrogenation, an operation of several hours at least is necessary in order to introduce into the oil the volume of hydrogen absorbed in one hour if pure hydrogen is employed.

TABLE I.—*Hydrogen Absorption in cc.*

Time in minutes.	Pure hydrogen.	Hydrogen containing 0·25 per cent CO.	Hydrogen containing 0·5 per cent CO.	Hydrogen containing 1·0 per cent CO.	Hydrogen containing 2·0 per cent CO.
2	35·0	30·8	27·1	25·0	6·0
5	86·4	72·3	66·6	57·6	28·1
10	143·4	121·8	111·2	92·6	57·0
15	193·9	158·6	142·2	115·5	76·2
20	247·9	193·1	168·4	135·9	91·2
25	298·9	224·6	191·6	151·0	103·4
30	348·4	252·4	213·0	164·2	113·8
35	392·0	279·1	232·2	179·5	122·2
40	437·2	305·1	249·8	193·0	130·4
45	478·9	328·4	266·2	202·9	138·6
50	515·0	351·6	281·2	214·5	145·9
55	550·0	373·8	295·8	224·8	152·6
60	584·5	393·8	309·6	235·2	158·8

An interesting result is obtained by plotting the total hydrogen absorbed in one hour against the percentage of carbon monoxide contained in the hydrogen absorbed (see Fig. 3). From this it will be seen that the first traces of carbon monoxide are comparatively the most harmful and that the inhibitive effect of successive increments in the carbon monoxide content decreases as the amount of carbon monoxide in the hydrogen increases, as shown by the rapidly decreasing slope of the curve with increasing carbon monoxide content.

The real poisoning effect of the various proportions of carbon monoxide, as distinguished from the purely obstructive or diluting action capable of being exerted by any foreign gas which accumulates in the gas space in the absorption vessel M and obstructs by its presence the free access of fresh hydrogen to the oil, may easily be obtained by calculating this diluting effect theoretically and subtracting this value from the total effect observed experimentally.

The following theoretical calculations of the retarding effect of the accumulation of a non-poisonous diluting gas is based firstly on the fact that the absorption of hydrogen by an unsaturated liquid, such as olive oil, in the presence of a catalyst conform to the usual velocity law for monomolecular reactions (Fokin, *Journ. Russ. Chem Phys. Soc*, 1908, xl., 276), and, secondly, that the velocity of absorption of hydrogen, in addition to following the above law, has been found by the author, in the course of an investigation of the effect of diminished hydrogen pressure on the reaction constant, to be approximately directly proportional to the hydrogen pressure for partial pressures of the order with which we are here concerned.

We have accordingly—

$$\frac{dx}{dt} = k(a-x)p \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

Where x is the volume of hydrogen absorbed by the 10 grms. of oil after time t, a the original hydrogen value of (or total volume of hydrogen absorbable by the quantity of oil taken), k the reaction constant, and p the partial pressure of the hydrogen in the free gas space above the oil.

If the hydrogen used contains m per cent of gaseous impurity then the volume of impurity remaining in the shaking vessel after a volume x of hydrogen has been absorbed by the oil is—

$$\frac{mx}{100-m}.$$

Accordingly, if V be the total gas space above the oil in the shaking vessel, a volume equal to—

$$V - \frac{mx}{100-m}$$

remains for the impure hydrogen, which, together with the accumulated impurity arising from absorbed hydrogen, occupies the gas space V. This volume of impure hydrogen will contain a fraction represented by—

$$\frac{100-m}{100}\left(V - \frac{mx}{100-m}\right)$$

of pure hydrogen.

The partial pressure of the hydrogen in the gas space is therefore—

$$\frac{100-m}{100\,V}\left(V - \frac{mx}{100-m}\right).$$

Substituting this expression for p in equation (1), we have—

$$\frac{dx}{dt} = \frac{k(100-m)}{100\,V}\left(V - \frac{mx}{100-m}\right)(a-x),$$

which becomes on integration—

$$\log_e \frac{\dfrac{2mx}{100-m} - \left(\dfrac{am}{100-m} + V\right) - \phi}{\dfrac{2mx}{100-m} - \left(\dfrac{am}{100-m} + V\right) + \phi} = \frac{k\phi t\,(100-m)}{100\,V} + \log_e \frac{-\left(\dfrac{am}{100-m} + V\right) - \phi}{\phi - \left(\dfrac{am}{100-m} + V\right)}$$

for cases where—

$$\left(\frac{am}{100-m} + V\right)^2 - \frac{maV}{25}$$

has a positive value designated for convenience by ϕ^2, from which, by solving for the values of x corresponding to time t, the theoretical absorption curves can be drawn.

For the series of experiments given above V is 12·14 cc., a is approximately 800 cc. for 15° C. and 760 mm. pressure, while k, calculated by applying the ordinary monomocular equation to the curve obtained for pure hydrogen, is approximately 0·0197, Napierian logarithms being employed.

The following table summarises the results of calculating the theoretical absorption curves according to the method described above:—

TABLE II.—*Hydrogen Absorption in cc.*

Time in minutes.	0·25 per cent diluting gas.	0·5 per cent diluting gas.	1·0 per cent diluting gas.	2·0 per cent diluting gas.
20	254	248	236	213
40	421	407	378	324
60	533	514	472	391

These curves, together with the theoretical curve for pure hydrogen according to the equation—

$$\frac{dx}{dt} = k(a-x)$$

are shown graphically in Fig. 4, which is on the same scale as Fig. 2.

On comparing the two sets of curves it will be seen firstly that the poisonous effect of carbon monoxide is far greater than the purely obstructive effect obtainable by the presence of a non-poisonous diluting gas in the hydrogen, and, secondly, that the theoretical pure hydrogen curve in Fig. 4 calculated for $k = 0·0197$ agrees quite well with the pure hydrogen curve obtained experimentally.

Summary.

The inhibitive effect of carbon monoxide has been studied from a quantitative standpoint for the hydrogenation of an unsaturated glyceride in presence of finely divided nickel as a catalyst.

A very marked poisoning influence was observed, and this poisoning effect was differentiated from the calculated obstructive effect of the impurity. It being found that the first traces of carbon monoxide have relatively the greatest retarding influence on the velocity of hydrogenation.

A detailed description is also given of an apparatus for following quantitatively the course of catalytic hydrogenation reactions generally.

THE CONSTITUTION AND HYDRATION OF PORTLAND CEMENT.*

By A. A. KLEIN (Worcester, Mass.).

(Concluded from p. 64).

Hydration of Portland Cement.

Having investigated the constituents of cement, the Bureau of Standard undertook to study the hydration of each and every constituent for the purpose of shedding light on the chemical and physical nature of setting and hardening and the nature of the rôle that each constituent played in these processes.

This solution of the problem went hand in hand with the determination of the constitution of cement. Vicot, as has been stated previously in this paper, observed the difference between it and the setting of lime plasters. A clearer conception of the processes was obtained by Le Chatelier, Richardson, and others using microscopic methods. Le Chatelier considered that the aluminate of lime in contact with water hydrated and hardened like plaster, according to the equation $3CaO.Al_2O_3 + 12H_2O = 3CaO.Al_2O_3.12H_2O$.

To this action was ascribed the initial set of the cement. The later hardening was ascribed, however, to the decomposition of the lime silicate. In contact with water it sets so as to give hydrated monocalcic silicate crystallising in microscopic needles and calcium hydroxide crystallising in large hexagonal plates according to the equation $3CaO.SiO_2 + H_2O = CaO.SiO_2.2\frac{1}{2}H_2O + 2(CaO.H_2O)$.

In the investigations of the Bureau of Standards the following compounds were synthesised and studied microscopically for time of hydration and for products of hydration under various conditions of temperature and pressure of the reacting water, $3CaO.SiO_2$, β-$2CaO.SiO_2$, γ-$2CaO.SiO_2$, $CaO\ SiO_2$, $3CaO.Al_2O_3$, $5CaO.3Al_2O_3$, and $CaO.Al_2O_3$. In addition to this, the hydration of mixture of two and three of these as well as of cement were studied microscopically (Klein and Phillips, Bureau of Standards, *Technical Paper* No. 43). This work was continued, and sufficient quantities of these products were made to test the compounds and mixtures for time of set, tensile strength, &c. (*Ibid.*, No. 78). The results of the above investigations have clarified the action of the different cement minerals on hydration and their influence on the strength of the hardened cement. The results may be briefly enumerated.

At early periods the constituents of Portland cement of normal composition and manufacture in the order of their strength-conferring properties are: The calcium silicate, tricalcium aluminate, and dicalcium silicate.

With an excess of water, tricalcium aluminate hydrates as the compound $3CaO.Al_2O_3.xH_2O$, where x varies with the drying conditions. 5 : 3 calcium aluminate and monocalcium aluminate, on hydrating, split off amorphous hydrated alumina and form the hydrated tricalcium aluminate. Under conditions of limited water such as encountered in concrete structure, the above crystallised compound does not form immediately, but separates from solution as an amorphous material. In steam at atmospheric pressure a little crystalline aluminate is formed with the amorphous material, still more in the autoclave, and finally, on microscope slides, the hydrated tricalcium aluminate is entirely crystallised. Wherever the amorphous aluminate is formed, it slowly but eventually changes to the crystallised compound.

The hydration of the aluminates begins readily in all cases. With an excess of water the reaction progresses rapidly, and in a few days the aluminates are completely hydrated. With restricted amounts of water, however, the individual aluminate grains become coated with amorphous hydrated aluminate through which further action proceeds with more or less difficulty. Tricalcium aluminate when used alone sets too rapidly and attains too little strength to be of any commercial value as a hydraulic cementing material.

The tests in steam at atmospheric pressure showed that the weakly basic aluminates do not absorb water above 110° C., while the more basic aluminates absorb water up to 140° C. Furthermore, a specimen of tricalcium aluminate containing high-burned free lime absorbs water even at 175° C.

The nature of the calcium hydroxide, formed by the hydration of free lime with much water, depends upon the fineness of the lime grains and the burning temperature. With coarser lime grains and with highly burned lime the hydration produces a preponderance of crystallised calcium hydroxide. On the other hand, with fine lime grains and with low-burned lime, mainly amorphous hydroxide is formed. Calcium hydroxide crystals are much more inactive chemically than the amorphous variety. White's solution, which attacks the amorphous hydroxide almost instantly, reacts extremely slowly with the crystals. In the autoclave the amorphous variety is not changed, whereas free lime yields according to its fineness and burning temperature crystallised and amorphous hydroxide. The crystals here often grow to large size, depending upon the length of time of reaction, the temperature, and the pressure.

The hydration of the aluminates in limewater reveals the same compounds as in distilled water. No new type of crystals which might indicate hydrated tetracalcium aluminate was observed. There does seem to be an action, however, between the hydrated alumina split off and the calcium hydroxide of the solution, resulting in a greater development of crystallised hydrated tricalcium aluminate.

Aluminates hydrated in the autoclave with an excess of limewater give no new type of compound. The plate crystals of hydrated tricalcium aluminate are rather poorly developed. The addition of dry calcium hydroxide up to 50 per cent decidedly retards the crystal growth of the aluminates in the autoclave.

The first effect of gypsum solution on the aluminates is to retard the formation of amorphous hydrated material and keep the pores of the material open to the further penetration of water. Specimens hydrated in saturated gypsum solutions show the highest ignition loss after six days. The products of hydration are the same as those with distilled water, with the exception of the additional formation of sulpho-aluminate needles. This new compound is identical for all three aluminates, and its formula is $3CaO.Al_2O_3.3CaSO_4.xH_2O$. The formation of this compound is only incidental to the initial set, and not the cause of its retardation, since the compound is formed before, during, and after the set. Variation of the gypsum content above and below a certain definite concentration causes a decrease in the setting time. Tricalcium aluminate containing 10 per cent plaster gains practically no strength after the first period at which it was tested, that is twenty-four hours.

The problem of initial set is probably one involving the action of small amounts of electrolytes in retarding the coagulation of the *amorphous aluminate material*. The evidence is in favour of the fact that the aluminates coagulate and separate as amorphous bodies from supersaturated solutions, the rate of coagulation being affected by such small quantities of electrolyte as to preclude the possibility of the reaction being solely a chemical one. Thus with a certain and definite concentration of gypsum, maximum hydration is attained, and at the same time the rate of coagulation is retarded, increasing the time of set.

The sulphoaluminate crystals are broken up in the autoclave, as is also gypsum. Club-shaped crystals are noted with optical constants that suggest a composition between gypsum and anhydrite. With higher temperatures and

* A contribution to a General Discussion on "The Setting of Cements and Plasters," held by the Faraday Society, January 14, 1918.

pressures water is even driven out of the amorphous hydrated aluminate. Gypsum favours the growth of hydrated tricalcium aluminate crystals in the autoclave.

Calcium metasilicate, as well as γ-calcium orthosilicate, is *practically inert with regard to hydration*. β-calcium orthosilicate is but slightly hydrated in water, until after a considerable length of time. This is manifested by a slight etching of the grains and the formation of a small amount of amorphous material, and crystallised calcium hydroxide. This cement mineral sets too slowly and attains strength too slowly to be of any commercial value *when used alone, although at periods beyond twenty-eight days* it gains sufficient strength to place it almost on an equality with tricalcium silicate. In mixtures of the β-orthosilicate and the aluminates the latter show some hydration, while the former is unhydrated after twenty-four hours, at which time cements are exposed hydrated, and the silicate shows quite a little hydration. The slides of β-calcium orthosilicate and aluminates indicate that the hydration of the aluminates proceeds as previously noted. Strength tests on briquettes of orthosilicate containing about 19 per cent of tricalcium aluminate (which is approximately the amount of aluminate present in cement) *show that the latter adds somewhat to the strength of the* former at later periods.

Homogeneous tricalcium silicate was not obtained, the most satisfactory product containing an extremely small amount of free lime, β-orthosilicate, and tricalcium aluminate. Tricalcium silicate acts entirely differently from either β-orthosilicate or mixtures of β-orthosilicate and lime, with respect to hydration. It hydrates readily with excess of water, with limited water, and in the autoclave. The products of hydration are identical, and consist of calcium hydroxide crystals and amorphous hydrated silicate. No hydrated calcium meta-silicate needles are observed. *It sets hard in five hours*, and possesses all the important properties of Portland cement, especially those of the rate of setting and strength developed. It shows no sign of disintegration after twenty-eight days in water and in the autoclave test. Here the size of the calcium hydroxide crystals depends upon the pressure. In general the greater the pressure the larger the crystals. Mixing tricalcium silicate with β-calcium orthosilicate has no favourable effect on the hydration of the latter.

Mixtures of tricalcium silicate and the aluminates gauged with water, limewater, and plaster solution show first the beginning of hydration of the aluminate, followed shortly by *the hydration of the silicate*. Tricalcium aluminate when used to replace 19 per cent of tricalcium silicate does not add to the strength of the latter, showing rather a tendency to decrease it at later periods.

The hydration of cements is thus brought about by the formation of amorphous hydrated tricalcium aluminate with or without amorphous alumina, the alumina later *crystallising*. At the same time sulphoaluminate crystals are formed, and low-burned or finely ground lime is hydrated. The formation of the above compounds begins within a short time after the cement is gauged. The next compound to react is tricalcium silicate, whose hydration begins within twenty-four hours. Between seven and twenty-eight days the amorphous aluminate commences to crystallise and β-orthosilicate begins to hydrate. Although the latter is the chief constituent of the American Portland cements, it is the least reactive compound. The early strength (twenty-four hours) of cements is probably due to the hydration of free lime, the aluminates, and the *beginning of tricalcium silicate hydration*. The increase in strength between twenty-four hours and seven days depends upon the hydration of tricalcium silicate, although the further hydration of aluminates may contribute somewhat. The increase between seven and twenty-eight days is due to any further hydration of tricalcium silicate and to the beginning of hydration of β-calcium orthosilicate, but here are encountered opposing forces, in the hydration of any high-burned free lime present and in the crystallisation of the aluminate. It is to this hydration that the falling off in strength between seven and twenty-eight days of very high-burned high-limed cements is due, whereas the decrease shown by the high-alumina cements is due to the crystallisation of the aluminate.

The dicalcium silicate hydrates to a very granular porous mass which allows of ready egress of solutions, and while *it is chemically more resistant to the actions of* solutions than the tricalcium silicate, yet it furnishes a great number of voids in which salts may crystallise out of solution, and it is consequently very little able to resist the mechanical action of the "freezing out" (crystallisa*tion) of salts from solution*.

On the other hand, the hydrated tricalcium silicate with its very dense structure, composed of gelatinous (colloidal) silicate interspersed with crystals of lime hydrate, is probably very susceptible to strains produced by alternate wettings and dryings, colloidal material of this kind being subject to considerable volume change resulting from *slight moisture changes*.

It appear, therefore, that the composition of Portland cement should be along lines which would not produce a great preponderance of either silicate. The ideal cement should possibly have an excess of the dicalcium silicate, which would give a not too dense hydrated material, gaining strength at later periods. A lesser amount of the tricalcium silicate would furnish the desired early strength and also overcome the excessive porosity of the dicalcium silicate.

It is possible to make a cement that will have the properties of Portland cement by grinding together the previously *separately burned constituents in approximately* the amounts in which they exist in Portland cement.

The function of tricalcium aluminate in the finished cement is somewhat problematical. A cement with less than 1 per cent of alumina has all the properties of Portland cement. Such a cement is, however, not a commercial possibility from the manufacturing standpoint, on account of the temperatures and amount of burning involved. It appears, therefore, that the aluminate in the finished cement is of the nature of a diluent or inert material, although it plays an important rôle in lowering the temperature of formation of trisilicate when the clinker is *burned*.

THE VISCOSITY OF BLAST-FURNACE SLAG AND ITS RELATION TO IRON METALLURGY, INCLUDING A DESCRIPTION OF A NEW METHOD OF MEASURING SLAG VISCOSITY AT HIGH TEMPERATURES.*

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(Concluded from p. 67).

Operation and Manipulation of Apparatus.

THE method of using the apparatus is as follows:—175 grms. of slag is placed in the graphite crucible. This quantity of slag when ground to 100 mesh, approximately fills the crucible. Although the height of the crucible internally is 3 in., the slag after having being melted and *cooled forms* a cylinder only about $1\frac{5}{8}$ in. in length. The crucible containing the slag is properly placed, and the upper removable part of the furnace is fixed in position. The crucible is then rotated, and the furnace is heated at such a rate that at the end of about an hour and a-half the slag reaches a temperature of 1200° C. The rate of heating is then *decreased in order that the large mass of slag may* acquire the temperature of the heating tube and diminish the lag effect. When the slag has become sufficiently fluid, as determined by several tentative lowerings of the

* A Paper communicated to the *Transactions of the Faraday Society*. Published by permission of the Director, U.S. Bureau of Mines

viscosity spindle, the suspension system is carefully lowered until the viscosity spindle rests on the bottom of the crucible. During this operation the rotation of the crucible is stopped in order to avoid the possibility of breaking the graphite spindle while it is being introduced into the viscous slag. The spindle is then raised exactly 0·5 cm. above the bottom of the crucible, the adjustment

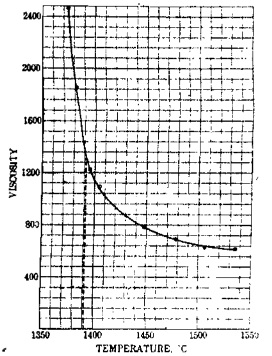

Fig. 4.—Temperature-viscosity relations of an artificial diopside.

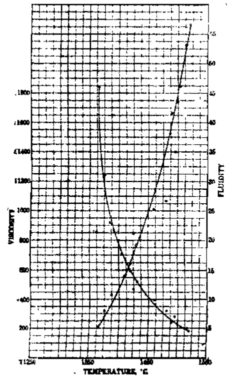

Fig. 5.—Relations of temperature to fluidity and viscosity shown in experiment with slag No. 22954.

being made by means of the scale in the apparatus support.

After the suspension system has been lowered and the depth of the viscosity spindle adjusted the temperature of the slag is slowly raised at a rate of 2—5° C. per minute, the temperature and scale deflection being noted at approximately regular intervals. When the highest temperature desired, usually 1500—1600° C., is reached, the heating current is so adjusted that the furnace cools at approximately the same rate that it was heated. Readings of deflection and temperature are

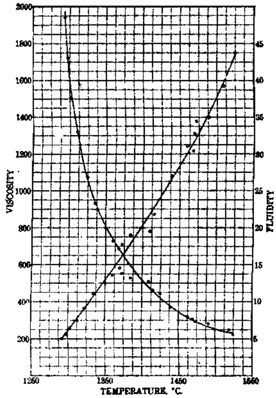

Fig. 6.—Relations of temperature to fluidity and viscosity shown in experiments with slag No. 22958. (This figure was inserted in error as Fig. 4 at p. 65).

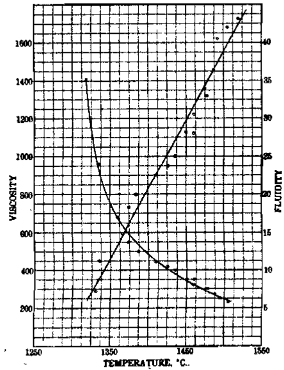

Fig. 7.—Relations of temperature to fluidity and viscosity shown in experiments with slag No. 23663.

taken until the maximum deflection (corresponding to a viscosity of 2000—3000) is reached. The spindle is then raised out of the slag before the latter becomes hard enough to prevent withdrawal.

Regulation of Speed of Rotation.—The electric motor used in rotating the furnace shaft was operated by a 110-volt storage battery, and showed a remarkably constant speed, which could be controlled by means of a rheostat. The time required for at least 30 revolutions of the shaft was taken by means of a stop-watch a number of times during each experiment. The slow speed of the furnace shaft (about 1 revolution per second) was obtained by means of suitable countershaft and pulleys between the motor and the furnace shaft.

Calibration of the Viscosity Apparatus.—The viscosity apparatus is calibrated against pure castor oil whose viscosity at ordinary temperatures is known. This method of calibration has been generally used by previous investigators, particularly by Doelter and Arndt.

Kahlbaum and Raber (87) have found that the viscosity of castor oil in C.G.S. units (100 times as large as those

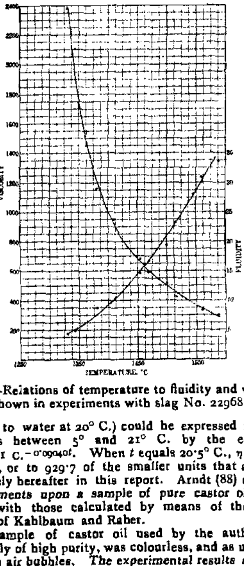

FIG. 8.—Relations of temperature to fluidity and viscosity shown in experiments with slag No. 22968.

referred to water at 20° C.) could be expressed for temperatures between 5° and 21° C. by the equation, $\eta = 59{\cdot}301\ \text{C.}^{-0{\cdot}09040t}$. When t equals 20·5° C., η is equal to 9·297, or to 929·7 of the smaller units that are used exclusively hereafter in this report. Arndt (88) obtained measurements upon a sample of pure castor oil which agreed with those calculated by means of the above formula of Kahlbaum and Raber.

The sample of castor oil used by the author was apparently of high purity, was colourless, and as used was free from air bubbles. The experimental results obtained in a calibration at 20·5° C. are given in Table V.

TABLE V.—*Calibration Data. (Distance of Scale from Mirror, 87 cm.).*

Scale deflection. Mm.	Time of 1 revolution of crucible. Seconds.	$K = \frac{(A \times B)}{87}$
57	1·90	1·25
62	1·77	1·26
73	1·45	1·21
85	1·24	1·21
105	1·04	1·25
110	0·966	1·22
118	0·890	1·21

A similar calibration with castor oil was made at 26° C. The viscosity calculated by means of a formula given by Kahlbaum and Raber for this temperature amounted to 394·4. The viscosity calculated from the calibration data obtained at 20·5° C. gave a value of 390·8. This agreement was considered satisfactory.

The temperature of the castor oil was in each case measured by means of a calibrated copper-constantan thermo-couple and a Wolff potentiometer.

Method of Calculating Results.

In a determination of slag viscosity a record was made of the temperature of the slag, the scale deflection, the distance of the scale from the mirror, and the speed of rotation of the furnace shaft. The values of K, representing a scale deflection in mm. at a distance of 1 cm. from the mirror at a speed of rotation of 1 revolution per second, were calculated in a manner similar to that used in the calibration data of Table I. For a spindle and suspension calibrated as described, the viscosity of the slag at various temperatures can be calculated by dividing the slag value of K by the observed castor oil constant and multiplying the result by 929·7, the viscosity of castor oil at 20·5° C.

Results of Viscosity Measurements.

The results of viscosity measurements on eight different slag samples (Lab. Nos. 22954, 22962, 22958, 22963, 24016, 23663, 22960 and 22968) are given in Table VI. for the temperature range 1275—1575° C. The composition of the slags is shown by the results of chemical analyses given in Table VII.

Temperature-viscosity curves were plotted, as shown in Figs. 5 to 8. The curves closely approximate in form a rectangular hyperbola. These curves contain all the experimentally determined points representing the temperature-viscosity relations observed in the heating and cooling of the slag sample. In this way any possible differences in the apparent temperature of the surface of the slag as measured by the optical pyrometer and the actual temperature within the slag mass are brought to light. On account of this fact, a smooth curve drawn through all the points must represent very closely the ideal conditions desired, the deviations tending to neutralise one another.

TABLE VI.—*The Viscosity of Typical Blast-furnace Slags at various Temperatures.*

(H_2O at 20° C. = 1).

Temp. °C.	Viscosity of slag, Lab. No.— 22954.	22962.	22958.	22963.	24016.	23663.	22960.	22968.
1275	—	—	—	1400	2600	—	—	—
1300	—	—	1700	1000	1500	—	1900	—
1325	—	—	1060	820	1080	2000	1100	3000
1350	2600	—	800	680	800	740	840	1800
1375	1150	—	640	540	620	560	640	1220
1400	750	3000	510	460	500	480	510	1000
1425	540	580	420	400	420	410	440	820
1450	410	480	350	350	350	360	380	680
1475	320	415	300	310	290	300	320	580
1500	230	380	260	280	250	250	280	480
1525	160	340	225	250	230	200	240	400
1550	—	290	—	220	205	—	—	340
1575	—	—	—	—	—	—	—	310

The temperature-fluidity curves for the four slags mentioned are also given in Figs. 5 to 8. The values were calculated by means of the familiar relation, Fluidity = 1/Viscosity. As was to have been expected from the general shape of the viscosity curves, the curves representing the fluidity at various temperatures approximate in form a straight line.

The actual experimental data obtained in the case of slag No. 22958 are given in Table VIII., which contains results obtained with rising and falling temperatures. Duplicate determinations on separate samples of slag gave results which agreed well within the known errors of measurement.

TABLE VII.—*Results of Analysis of the Eight Slags.*

Lab. No.	Composition of slag—Percentage of— SiO₂.	Al₂O₃.	Fe₂O₃.	FeO.	Fe.	TiO₂.	CaO.	MgO.	MnO.	CaS.	Alkalis.	Moisture.	Total.
22954	18·30	35·30	0·00	0·47	0·05	0·58	31·24	9·69	0·35	4·07	0·50	0·02	100·57
22962	31·54	14·79	0·00	0·07	0·22	0·29	47·65	1·80	0·21	3·56	—	0·10	100·23
22958	33·67	26·62	0·00	0·28	0·51	0·28	26·67	6·43	0·33	4·86	—	0·12	99·77
22963	34·27	13·78	0·00	0·07	0·28	0·56	41·30	6·39	0·55	3·35	—	0·04	100·59
24016	35·76	13·36 (*a*)	—	—	—	—	42·11	3·94	0·49	3·70	—	—	99·36
23663	36·04	12·10 (*a*)	—	—	—	—	42·04	4·03	0·35	3·92	—	—	98·48
22960	37·18	11·46	0·00	0·31	0·11	0·52	25·33	19·58	2·21	3·51	—	0·04	100·25
22968	43·56	9·48	0·00	0·21	0·38	0·19	40·18	2·08	0·21	2·75	0·52	0·05	99·59

(*a*) Includes Fe and FeO as Fe_2O_3.

TABLE VIII.—*Comparison of Viscosity Values obtained with Rising and Falling Temperatures.*

(Results obtained in experiments with slag designated Lab. No. 22958).

Rising temperature. Tempera-ture, °C.	Viscosity.	Falling temperature (*a*). Tempera-ture, °C.	Viscosity.	Tempera-ture, °C.	Viscosity.
1382	605	1292	1940	1382	611
1410	513	1297	1707	1387	524
1415	460	1302	1505	1425	446
1425	442	1312	1319	1440	375
		1322	1074	1466	323
1463	320	1337	922	1470	304
		1350	805	1488	285
1473	291	1359	728	1525	228
1510	255	1368	689		

(*a*) Results are given in reverse order, for easy comparison with results under "Rising temperature."

In Table IX. are given the results of duplicate determinations on slag No. 23663. The deflections observed with falling temperature are given for both slags, these deflections being proportional to the viscosity of the melt.

TABLE IX.—*Duplicate Measurements on Slag No.* 23663.

Temperature, °C.	Original deflection.	Temperature, °C.	Duplicate deflection.
1510	26	—	—
1487	31	1487	32
1477	34	1472	34
1460	38	—	—
1450	39	1450	40
1435	40	1440	40
1425	42	1430	43
1410	44	1410	45
1387	48	1387	48
1337	90	1347	82

General Appearance of Slag Melts.

When cold the slag was easily removed from the graphite crucible by pressing on the bottom of the melt through the hole into which the graphite crucible support is threaded. The slag on cooling shrinks away from the graphite crucible wall sufficiently to prevent objectionable binding and sticking. The melt as taken from the crucible is cylindrical, with an upper surface which is almost flat, as the viscosity at the moment when the spindle was withdrawn was not great enough to prevent the slag from flowing into the space previously occupied by the graphite spindle.

Plate III. shows photographs of six fragments of slag melts after removal from the crucible. Samples Nos. 1 and 3 (reading from left to right) are the upper and lower portions of the same melt (slag No. 22968). Sample No. 2 is a fragment of melt from slag No. 22954, while sample No. 4, containing the lower end of a viscosity spindle embedded in it, is a fragment from a duplicate determination on the same slag. In this case the spindle was not removed soon enough, and in attempting to do so the shaft was broken off at the surface of the melt. Sample No. 5 is a fragment of the artificial diopside melt used in calibrating the black-body conditions of the furnace, as described hitherto. The crystalline structure of this melt is easily seen from the photograph. Sample No. 6 (on the extreme right of photograph) is a fragment of a synthetic slag melt which does not differ considerably in composition from that of gehlenite, $2CaO.Al_2O_3.SiO_2$. The network of large crystals seen in the photograph of this melt are presumably crystals of gehlenite.

Samples 1 to 4 also show the presence of numerous smaller crystals easily visible with the naked eye.

However, the crystalline structure of the cooled slag was not studied systematically in connection with the experiments reported.

The separation of metallic iron, owing to the strongly reducing atmosphere of the furnace, and the duration and intimacy of contact between molten slag and the furnace atmosphere, was frequently observed. These metallic globules were found mostly on or near the surface of the cooled melt; some were 2 to 3 mm. in diameter. Their formation was only noted in the case of slags abnormally high in iron.

Discussion of Experimental Measurements.

The measurements described above give for the first time an accurate idea of the actual magnitude of the viscosity of blast-furnace slags in units which are capable of a physical interpretation, as well as of the rate of change of viscosity of different slags with temperature over a wide range of temperature and viscosity.

If an average slag temperature of 1500° C. is assumed, an examination of the data given in Table V. discloses the fact that the viscosity of the normal blast-furnace slag as it flows from the cinder-notch approximates 250 (H_2O at 20° C. = 1). This represents a viscosity less than that of castor oil at room temperature, but greater than that of olive oil.

The viscosity of the eight slags considered in Table V., at a temperature of 1500° C., varied from 230 to 480. A synthetic slag, upon which measurements have been recently made, showed a viscosity of 770 at 1500° C., this slag containing 48 per cent silica; while reference to Fig. 4 shows that at this temperature the artificial diopside containing 55 per cent silica had a viscosity of 640. The effect of silica in such amounts upon the viscosity of silicates at temperatures above their melting-points is thus clearly demonstrated, the increase in viscosity over that of normal slags being marked, even in the case of diopside, which contains no alumina and a high percentage of magnesia.

It would seem that even such high percentages of alumina as are present in the slag designated Lab. No. 22954, although causing a high initial softening temperature, do not have a very noticeable effect in increasing the viscosity of the melt at high temperatures. This peculiar property of alumina, which may be a quite general characteristic, is probably associated in some manner with the uncertainty of its action within the furnace.

Comparison of Viscosity Measurements with Cone Tests.

It was thought a matter of interest to compare the results of viscosity measurements with cone tests made with corresponding slags. The cone tests were made, as has been previously described, under conditions which converted the sulphide content of the slag to the state of the sulphate. For this reason the comparison is not a strict one. In Table X. is given in relative order the softening temperature of six slags and their viscosities at 1400°, 1450°, and 1500° C.

TABLE X.

Slag Lab. No.	Softening temperature, °C.	Viscosity at— 1400°.	1450°.	1500°.
22958	1279—1279	1000	680	480
22960	1297—1300	510	380	280
22958	1342—1342	510	350	260
22963	1343—1360	460	350	280
22954	1410—1410	750	410	230
22962	1403—1443	3000	480	380

The method of preparing and mounting the test piece in the determinations of softening temperatures has been previously described (89).

Summary.

1. There has been described a modification of the torsion method of Margules which is applicable to the measurement of the viscosity of blast-furnace slag at high temperatures—the upper limit of temperature, 1600° C., being imposed by the furnace refractories and not by inherent limitations in the viscosity apparatus.

2. Viscosity values are given for eight commercial slags, two synthetic slags, and an artificial diopside.

3. The temperature-viscosity curve approximates in form that of the rectangular hyperbola, whereas the temperature-fluidity curve, being the reciprocal of the temperature-viscosity curve, approaches a straight line in form.

4. The average viscosity at 1506° C. of eight commercial slags was found to be 301 (H_2O at 20° C. = 1).

5. A refractory slag—that is, a slag possessing a high initial softening temperature—is not necessarily more viscous at high temperatures than a more fusible slag.

6. The theory of the method of measurement has been discussed, and the literature on slag viscosity and high temperature viscosity measurement has been briefly reviewed.

7. The application of viscosity data to metallurgical operations has been discussed, as well as the blast-furnace desulphurisation process and its relation to slag viscosity.

8. The differences between softening temperature determined by a deformation method, the physical melting-point of slags, and the viscosity of slags have been emphasised.

9. The nature of the free-running temperature of slags and the measurement of slag temperature at the furnace have been discussed.

10. The relation of slag viscosity to the fuel economy of the blast-furnace has been considered briefly.

11. Suggestions have been made as to the cause of the high viscosity of silica and silicates in the light of recent researches by the Braggs on crystal structure.

Notes.

87. Kahlbaum and Raber, *Acta. Ac. Leop.*, 1905, lxxxiv., 204; see also Kurt Arndt, "Die Messung der Zähigkeit," *Zeits. Chem. Apparatenkunde*, 1908, iii., 549.

88. K. Arndt, (Note 64).

89. A. C. Fieldner and A. L. Feild, "A New Method and Furnace for the Determination of the Softening Temperature of Coal-ash under Fuel-bed Conditions," *Journ. Ind. and Eng. Chem.*, 1915, vii., 829.

THE ORES OF COPPER, LEAD, GOLD, AND SILVER.

By CHARLES H. FULTON.

(Continued from p. 69).

Ores containing Lead Minerals. (Chiefly argentiferous galena associated with a large amount of gangue in vein deposits).

Cœur d'Alene, Idaho.—The ore deposits are veins in slates, quartzites, and greywackes. The ore minerals are argentiferous galena, pyrite, and blende, and the gangue minerals are chiefly siderite and quartz. The average metal content of the ores taken as a whole is 6 to 10 per cent lead and 3·5 to 7 ounces of silver per ton. The ore is divided into two classes as follows:—(1) High-grade or shipping ore and (2) concentrating ore. The ore of the first class comprises one-tenth to one-fourth of the total production. Typical analyses are given in Table IV.

TABLE IV.—*Analyses of Typical High-grade Ore from Cœur d'Alene, Idaho.*

	Sample No. 1.	Sample No. 2.
Gold	None	None
Silver, per ton (ounces)	37·9	11·0
Lead (per cent)	42·4	41·4
Copper	None	None
Silica (per cent)	13·4	11·0
Iron (per cent)	15·7	16·0
Lime (per cent)	1·1	1·2
Zinc (per cent)	4·1	1·3
Sulphur (per cent) ..	11·0	7·5

The concentrating ore has approximately the following composition:—Lead, 5 to 14 per cent; iron, 24 to 27 per cent; silica, 23 to 26 per cent; silver, 4 to 7 ounces per ton. The ratio of concentration is about 8 to 1, and the recovery by concentration varies in different mills from about 76 to 90 per cent of the lead and 50 to 85 per cent of the silver. Typical analyses of concentrate are given in Table V.

TABLE V.—*Analyses of Typical Concentrate Ore from Cœur d'Alene, Idaho.*

	Sample No. 1.	Sample No. 2.
Gold	None	None
Silver, per ton (ounces)	44·2	18·3
Lead (per cent)	52·8	52·9
Copper	None	None
Silica (per cent	9·0	4·6
Iron (per cent)	13·8	14·0
Lime (per cent)	0·9	1·2
Zinc (per cent)	3·8	1·5
Sulphur (per cent) ..	12·0	10·3

The ore from some of the mines contains considerable zinc, and at some of the mills, as the Green-Hill-Cleveland mill at Wallace and the Morning mill at Mullan, certain fine products of the mill are treated by flotation processes for the recovery of both the zinc and the lead sulphides.

Aspen, Colo.—The ores consist of native silver, argentiferous galena, pyrite, argentiferous barite, sphalerite, and smithsonite in a gangue of limestone and quartz. Formerly much high-grade ore was mined and smelted direct. Now most of the ore must be first concentrated. As an example of ore composition the following analysis is given:—Lead, 5 to 9 per cent; silica, 15 to 25 per cent; barite (barium sulphate), 15 to 20 per cent; lime, 8 to 12 per cent; magnesia, 3 to 5 per cent; iron, 8 to 15 per cent; zinc, 3 to 8 per cent; copper, 0·16 per cent; sulphur (exclusive of that combined in the barite), 7 to 10 per cent; silver, 10 to 15 ounces per ton. The concentration is about 4 to 1, typical concentrate having the following

* *Technical Paper* 143, Department of the Interior, U.S.A. Bureau of Mines.

Table III.—*Ores all taken from Leadville, Colo.*

Class of ore.	Composition, Gold, per ton. Ounces.	Silver, per ton. Ounces.	Lead. Per cent.	Copper. Per cent.	Insoluble. Per cent.	True silica. Per cent	Iron and manganese.(a) Per cent.	Zinc. Per cent.	Sulphur. Per cent.
Iron oxide..	None	9·00	1·00	None	16·1	—	48·00	—	0·4
Siliceous dry oxide	0·48	2·40	1·50	—	46·4	34·20	32·20	0·40	1·4
Siliceous lead oxide	0·38	7·30	16·80	—	44·6	40·2	17·0	—	1·5
Dry carbonate	0·47	8·60	—	—	33·4	30·1	39·2	—	1·1
Lead carbonate	18·1	14·70	—	—	30·7	27·6	24·2	6·00	0·7
Siliceous dry sulphide	0·75	6·7	4·6	0·90	60·1	54·1	9·00	8·6	12·3
Iron dry sulphide	0·25	17·1	2·5	2·90	18·00	16·2	28·00	5·3	High
Iron sulphide	0·04	4·8	2·4	—	3·30	—	46·00	6·4	High
Siliceous lead sulphide	0·07	7·5	12·1	0·80	22·70	20·4	23·3	7·5	13·1
Iron lead sulphide	0·45	13·4	7·1	2·1	14·8	13·4	32·0	2·9	—
High lead sulphide (b)	0·02	7·2	7·9	—	7·3	6·6	39·0	12·4	19·8
	0·02	19·9	60·1	0·30	2·00	1·8	9·1	7·2	High
	0·01	9·0	38·3	—	3·00	2·1	15·2	13·2	26·8

(a) Chiefly iron. (b) CaO, 0·6 per cent.

analysis:—Silver, 5 ounces per ton; lead, 23·5 per cent; copper, 0·1 per cent; silica, 11·9 per cent; iron and manganese, 2·5 per cent; lime, 18·1 per cent; zinc, 1·3 per cent; sulphur, 5·8 per cent.

Ores containing Lead and Zinc.

The complex ores containing lead, zinc, and the precious metals, and sometimes copper, present the ores most difficult for successful metallurgical treatment. Processes for their treatment are discussed in detail in Technical Paper 90 of the Bureau of Mines (D. A. Lyons and others, "Metallurgical Treatment of the Low-grade and Complex Ores of Utah," 1915, p. 40).

Ores containing Lead and Zinc Commercially free from Precious Metals.

South-Western Missouri.—The South-Eastern Missouri ore contains galena, sphalerite, pyrite, and marcasite in a gangue of limestone and flint, and carries 2 to 3 per cent lead and 3 to 10 per cent zinc. It is concentrated into two products as follows:—(1) Galena concentrate, containing 76 to 83 per cent lead, and not more than 2 to 3 per cent iron and zinc, and (2) sphalerite concentrate, containing 62 per cent zinc and not more than 0·2 per cent lead, and up to 4 per cent iron. The galena concentrate is treated by lead smelting and the sphalerite concentrate by zinc smelting.

Lead-zinc Ores containing Precious Metals.

Broken Hill, New South Wales, Australia.—The New South Wales ores consist of argentiferous galena and sphalerite and some pyrite in a gangue of quartz, rhodonite, rhodochrosite, garnet, and calcite. At the several mines the composition of the ores differs in the proportion of the sulphide and gangue minerals, and in the nature of the occurrence of the sulphides, such as their fineness of dissemination and the intimateness of their mixture, which affect the ore-dressing operations for the separation of zinc and lead. The presence of gangue minerals, such as rhodonite (silicate of manganese), which have a specific gravity approximating that of zinc blende, was the cause of much difficulty in the ordinary water concentration process, and led to the making of a high-grade lead concentrate and a tailings or waste product containing most of the zinc. This waste product by means of the new "flotation" process, is now successfully concentrated into a high-grade zinc product containing little lead. The composition of typical ore follows:—Lead, 10 to 15 per cent; zinc, 15 to 25 per cent; silver, 8 to 15 ounces per ton. Such ore is concentrated into a lead product of about the following composition:—Lead, 53 per cent; zinc, 10 per cent; silver, 32 ounces per ton; and a zinc product containing, for example, zinc 43 per cent, lead 10 to 12 per cent, silver 10 to 20 ounces per ton. The tailings or refuse from the first water concentration are treated by the flotation process, and give rise to a zinc product or concentrate of the above composition.

Creede, Colo.—The Creede, Colo., ore bodies are veins in eruptive rock (rhyolite). The ore consists of galena, sphalerite, pyrite, and some gold and silver (probably as argentite) intimately mixed and disseminated through a gangue of quartz and altered rhyolite—a highly siliceous eruptive rock. The ore contains about 11 per cent lead, 5 per cent zinc, 2·5 per cent iron, and 60 per cent silica. It is concentrated into two products—(1) a lead concentrate, of which the following is a typical analysis:—Gold, 0·31 ounce per ton; silver, 10·9 ounces per ton; lead, 62·1 per cent; copper, 0·1 per cent; silica, 18·2 per cent; iron, 8·6 per cent; zinc, 4·9 per cent, and considerable sulphur; and (2) a zinc concentrate that contains, approximately, 36 to 45 per cent zinc, 2 per cent iron, 13·5 per cent silica. About 1 ton of concentrate is derived from 7 to 8 tons of ore. The one product goes to the lead smelter and the other to the zinc smelter.

Park City, Utah.—The Park City, Utah (Daly-Judge mine), ore consists of argentiferous sphalerite, galena, and pyrite in a gangue of limestone and quartzite. It has the following average composition:—Lead, 10 per cent; zinc, 9 per cent; silver, 7 ounces per ton. The ore is concentrated into two products—(1) galena concentrate, containing lead, 33 per cent; zinc, 7 per cent; iron, 21 per cent; silica, 3 per cent; silver, 18·5 ounces; and gold, 0·06 ounce per ton; (2) zinc concentrate, containing 2 to 4 per cent lead, 25 per cent zinc, 15 per cent iron, 8 per cent silica, 5 ounces of silver, and 0·02 ounce of gold per ton. About 3·75 to 4 tons of ore is concentrated into 1; the amount of the lead concentrate is about twice that of the zinc concentrate.

(To be continued).

EMPIRE TRADE NOTES.*

Dominion Manufacturing Development.

It will probably surprise a good many people to learn that South Africa in 1915-16 produced manufactured goods to the approximate value of £36,000,000, but the figures are established by the official census of manufacturers recently taken in the Union. This production was, of course, mainly consumed in South Africa, which is now learning to manufacture for itself many of the things which it used to import. Canada's industrial development is, of course, much older and more advanced, and that Dominion has for some time been sending certain of her manufactures to

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Europe. In 1916 a Canadian Government Special Trade Commission visited the United Kingdom, France, and Italy and issued a suggestive report on the possibilities of extending the sale of Canadian products, manufactured as well as raw, in those countries. These things are signs of the times. The old ingenuous theory of the Dominions as purely agricultural communities and of Great Britain as a purely manufacturing one has perished for ever. But while in the future there will be certain things which it will be best for the Dominions to make for themselves, there are others which for a long time to come, at all events, Europe should be able to supply. The United Kingdom has to see that where Europe is concerned she, and not some other European manufacturing country (Germany for instance), shall be Canada's source of supply. And, on the other hand, she must see that she herself and not some other European country has the first call on the Dominions' vast resources in raw material. This is the only way in which, as the British Empire Producers' Organisation sees the matter, Imperial resources can be developed to the maximum advantage of the whole Empire as well as of its parts.

Natal's New Industry.

In Natal a considerable industry is now being built up by the utilisation of the wax, hitherto wasted, which is a by-product of cane sugar manufacture. The British Empire Producers' Organisation understands that the process of extracting the wax was invented by a Dutch chemist, has been carried on in Java, and tried experimentally in Mauritius. To Natal, however, belongs the honour of being the first British possession to operate the process on a commercial scale. The wax, which is equal in value to and chemically almost identical with beeswax, is produced from the filter-press cake of the sugar factories. The residue of the filter-press cake, after the wax has been extracted, is used as a fertiliser for the cane-fields, while the wax itself, which has a high melting point and takes a very high polish, is being used by boot manufacturers and furniture manufacturers in South Africa, and also exported for the same purpose to London. As the demand is said to be unlimited, the prospects of the new industry seem particularly bright. There seems no reason why a similar industry should not be started in some of the West Indian sugar colonies.

Sugar in Egypt.

The British Empire Producers' Organisation notes that the war has materially aided the Egyptian cane sugar industry. Before the war the Egyptian, like the West Indian, industry suffered badly from the competition of German and Austrian beet. With the removal of these imports the area under cane in Egypt was materially extended. Whereas in the ten years, 1904-1913, the Egyptian production was only 60,000 tons, in 1916 it was 100,000 tons, and both local consumption and export have greatly increased, the latter from 5000 tons in 1913 to 29,000 tons in 1916. In addition, the British forces in Egypt have been drawing all their sugar supplies from the country. The retail supply has meanwhile remained ample, and the price—about threepence per pound for the best refined sugar—should be noted by the people of this country, who are paying double and are strictly rationed. Even allowing for the fact that sugar has to be imported into the United Kingdom, and, when it gets here is taxed, the Egyptian price remains an object-lesson in the value of national production.

Indian Hides and British Tanners.

Various steps, the British Empire Producers' Organisation understands, have already been taken to secure that after the war the British—not the German—Empire shall benefit from India's wealth in hides. Many German hide-buying firms in India have been eliminated, and British firms are being stimulated to enter this profitable business. The ultimate object in view is the tanning of all Indian hides by British tanners in various parts of the Empire, and comprehensive as this policy is it is considered by experts to be quite within the limits of the practical. Prior to the war the Indian hide trade was almost entirely in German hands, and Germany and Austria together were taking 70 per cent of India's production, the balance being tanned by British firms in India. At present the British Government is the sole buyer of Indian hides, acting through a buying committee of leading British firms set up by the Government of India. From this buying committee members of the old German buying "ring" in Calcutta, whatever their nationality, were, it is understood, to be excluded. This sensible policy once adopted, the Indian Government seem, however, to have repented of it, and to have suggested that the English buying firms should work in conjunction with members of this old German "ring." The English buying firms have very properly refused to have anything to do with such a proposal. They look to the British Government to see that their efforts to make the Indian hide business, from raw material to finished leather, a British enterprise throughout shall not be hampered by official flabbiness in India. This matter is of vital importance to the British Empire.

Failing a practical interest in Indian hides by British tanners Germany will, after the war, once more be able to control the trade, and, incidentally, as in the past, make her army's boots out of Indian raw material.

Indian Cotton.

Giving evidence before the Indian Cotton Committee, to the sittings of which in India reference has already been made by the British Empire Producers' Organisation, the Government of India's Economic Botanist for the United Provinces laid great stress on the necessity of improving the best native cottons rather than wasting time in the endeavour successfully to acclimatise the American imported type. This expert believes that within a reasonable time the two best types of native cotton can be improved so as to be of an inch staple, and thus equivalent to the grade known as middling American. This is a very interesting opinion, and if supported by further substantial expert evidence may have important results.

New Enterprises in South Africa.

A company to promote industrial development has been started in South Africa by a few financial institutions which have repeatedly been told that it is only lack of capital that has delayed the more rapid growth of manufactures in the Union. Applicants are asked to satisfy the company that their business is sound and likely to succeed, that they can conduct it with efficiency, that the undertaking is naturally suitable to the country, and likely to prove permanent—for instance, that the raw materials are produced in South Africa. If and when this has been done the company is prepared to render financial assistance to the promoters of new enterprises, thus fulfilling the purposes, it would seem, of what is generally known as a trade bank. The actual utility to South Africa of such a company or bank must, of course, depend in the main on the business, technical, and scientific knowledge of those who manage it, but the British Empire Producers' Organisation is, needless to say, quite in sympathy with the principle involved.

Quicksilver in New Zealand.

A bonus of 4d. per lb. for the first 100,000 lbs. of retorted quicksilver produced from New Zealand mines has been offered by the New Zealand Government. The conditions are that at least one half of the quantity is produced before March 31, 1920, and the remaining half before March 31, 1921. The first instalment of the bonus will be paid when 50,000 lbs. of quicksilver have been produced. A similar offer has been made before without result, but it may be hoped that the increased attention which is now being given to schemes for the development of Empire resources may lead to the bonus being ulti-

mately earned. The British Empire Producers' Organisation states that quite recently the only mining for quicksilver in progress in New Zealand was at Puhipuhi, North Auckland. The Puhipuhi range is thought to be a likely field for important mineral discoveries, but in various parts of New Zealand occurrences of quicksilver ore have been recorded from time to time. Cinnabar was found in the early alluvial diggings in Nevis, Nokomai, Waipori, and Waitahuna, in Otago, and promising samples, yielding 84 per cent of quicksilver, were discovered at the Upper Nevis in 1883. Some prospecting was done, but the lode was not found. An occurrence of mercury ore at the Ohaeawai Hot Springs in Bay of Islands county is believed to be important, and an effort has been made to mine the ore and recover the mercury therefrom. Though the ore is low-grade, mercury occurs in some quantity. Ores of mercury have also been discovered at several points in Whangaroa, North Island.

NOTICES OF BOOKS.

The Chemical Constitution of the Proteins. Part I. *Analysis.* By R. H. A. Plimmer, D.Sc. Third Edition. London, New York, Bombay, Calcutta, Madras: Longmans, Green, and Co. Pp. xii+174. Price 6s. net.

The third edition of this monograph, which contains a considerable amount of new matter, has been divided into two parts, and thus a saving of labour has been effected and the outlay of the purchaser lessened. Part I. deals only with the analysis of the proteins in which the greatest progress has been made in the last few years. The isolation and estimation of the constituents is described in the fullest detail, and the whole text has been carefully revised. Copious tables of analytical data are included, and the monograph will be found indispensable by workers of this branch of biochemistry.

Quantitative Chemical Analysis. By Frank Clowes, D.Sc. Lond., and J. Bernard Coleman, A.R.C.Sc. Dublin. Eleventh Edition. London: J. and A. Churchill. 1918. Pp. xxiv+580. Price 12s. 6d. net.

Each successive edition of this highly valued text-book of analysis has been amplified, and the text corrected when necessary, and the book has now grown to such a size that in scope and in detail it will be found quite adequate to meet the requirements of analytical and consulting chemists as well as those of advanced students. No better book could be found upon which to base an extended course of quantitative analysis, and it thoroughly deserves its success. Typical methods of analysis as applied to various industrial products are now described in full detail in one section, which has been very considerably extended, and tables of results and of all numerical data required in analytical work are included. In the section on gas analysis the descriptions of some of the more elaborate and complicated methods are omitted to make room for other matter, and references are given to standard works dealing with gas analysis only in which are to be found the full accounts of the methods which for adequate treatment would require more space than could satisfactorily be allotted to them in this book.

Osmotic Pressure. London: The Faraday Society. 1917. Pp. 73. Price 7s. 6d.

This pamphlet contains a verbatim report of the general discussion on osmotic pressure which was held by the Faraday Society in May, 1917, Sir Oliver Lodge in the chair. The subject was treated from three different points of view, the opening paper being read by Prof. Alfred W. Porter, who dealt with the kinetic theory of osmotic pressure. Dr. F. Tinker contributed a paper on the properties and function of the colloidal membrane, and Mr. W. R. Bousfield considered the question from the point of view of the action of the solvent and the hydration of the solute. The discussion which followed the reading of the papers was exceedingly interesting, and it was unfortunate that time would not allow of the consideration of some of the important points which where raised. The reprint contains some communications which were received subsequent to the meeting, and also the replies of the authors to some criticisms.

MISCELLANEOUS.

Determination of Phosphoric Acid and Magnesium.—M. Bauzil.—Magnesium and phosphoric acid can very readily be determined by a method based upon the behaviour of acid phosphates towards methyl-orange, the equation representing the reaction being $2PO_4MgNH_4+4HCl=2MgCl_2+2PO_4NH_4H_2$. The phosphoric acid is first precipitated by ammoniacal magnesium mixture, and the precipitate is filtered off and washed with water containing ammonia, and with alcohol. It is then suspended in water, and to the same quantity of distilled water in another flask ten drops of methyl-orange are added, and the number of cc. of normal hydrochloric acid, say, *a* cc., necessary to produce a red coloration, is determined. The same operation is performed with the suspended precipiitate. Then if *n* is the number of cc. of HCl required in the second case, the amount of phosphoric acid, P_2O_5, present is given by $(n-a)\times 0.00355$, and the amount of MgO by $(n-a)\times 0.002$.—*Journal de Pharmacie et de Chimie*, 1917, xvi., No. 11.

Institution of Petroleum Technologists.—The possibility of producing, from home sources hitherto neglected, a certain proportion of the vast amount of mineral oil and its kindred products, now so vital a necessity to our national existence, has been much canvassed for some time past in both the general and technical press, and at the next meeting of the Institution of Petroleum Technologists, on the 19th instant, at 8 p.m., at the House of the Royal Society of Arts, Adelphi, W.C., a paper will be read dealing with the subject entitled "A New British Oil Industry," by Mr. E. H. Cunningham Craig, Dr. F. Mollwo Perkin, Mr. A. G. V. Berry, and Dr. A. E. Dunstan. The President of the Institution, Mr. Charles Greenway, will occupy the chair.

MEETINGS FOR THE WEEK.

Monday, 18th.—Royal Society of Arts, 4.30. (Cantor Lecture): "The Economic Condition of the United Kingdom before the War—the Real Cost of the War—and Economic Re-construction," by Edgar Crammond.

Tuesday, 19th.—Royal Institution, 3. "Problems of British Anthropology," by Prof. Arthur Keith.
— Institution of Petroleum Technologists, 8. "A New British Oil Industry," by E. H. Cunningham Craig, F. M. Perkin, A. G. V. Berry, and A. E. Dunstan.

Wednesday, 20th.—Royal Society of Arts, 4.30. "Picturesque Architecture," by Maurice B. Adams.
— Microscopical, 8. "Photo-synthetic Action induced in Living Cells, and their Products," by Prof. B. Moore. "Illustrations of Preparations," by Col. Rawson.

Thursday, 21st.—Royal Institution, 3. "Three French Moralists and their Influence on the War—La Bruyere," by Edmund Gosse, C.B.
— Royal Society. "Scattering of Light by Spherical Shells and by complete Spheres of Periodic Structure when the Refractivity is Small," by Lord Rayleigh. "Nature of Heat as directly Deducible from the Postulate of Carnot," by Sir Joseph Larmor. "Curved Beams," by J. J. Guest. "Monoclinic Double Selenates of the Iron Group" and "Selenic Acid and Iron—Reduction of Selenic Acid by Nascent Hydrogen and Hydrogen Sulphide—Preparation of Ferrous Selenate and Double Selenates of Iron Group," by A. E. H. Tutton.

Friday, 22nd.—Royal Institution, 5.30.

Saturday, 23rd.—Royal Institution, 3. "Problems in Atomic Structure," by Sir J. J. Thomson.

THE CHEMICAL NEWS

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CRYSTALLOIDS AGAINST COLLOIDS IN THE THEORY OF CEMENTS.*

By HENRY LE CHATELIER (Paris).

I HAVE always opposed the theory which attributes the hardening of cements to certain colloidal properties of the material, as being devoid of sense. In a similar way it used to be said that bodies react because they have affinity for each other. Henri Sainte-Claire Deville maliciously remarked that, since affinity was by definition the tendency of bodies to react with each other, that explanation of chemical reactions came down to this: the bodies react because they have the tendency to react. The actual explanation of the hardening of cements is of an analogous kind, I am afraid. People evade defining what they call a colloid, but they seem to take the word in the sense of a body capable of hardening. And then the explanation comes down to this: cements harden because they have the property of hardening. Similar tautologies would easily be avoided if the excellent principle of Pascal were more frequently applied: "Before you enounce a statement, begin always by replacing mentally each word by its definition."

After this general remark let us approach the problem more closely. Begin by defining the word "colloid," if that be possible. Graham, the originator of the discovery of the bodies which are thus designated, had recognised the existence of two sorts of different solutions. The one kind gave on evaporation crystallised bodies called *crystalloids* (sea-salts, sugar, &c.), the other gave amorphous gelatinous materials called *colloids* (gelatinous silica, gum, &c.). He further recognised that the crystalloids are diffused when dissolving and that the colloids are not.

More recently Zsigmondy showed with the aid of the ultramicroscope that the colloidal solutions were not true solutions, but merely suspensions of very finely divided, rigorously insoluble matter. These suspensions are opaque, milky, or transparent, according to the fineness and the abundance of the particles so suspended in the liquid. When their diameter is inferior to the wave-length of light, they allow the light to wend its way through, somewhat as happens in the case of sound with screens of a limited size. The diameter of the true colloids approaches a millionth of a millimetre, and is always much less than a thousandth of 1 mm.

All very minute insoluble bodies give such colloidal suspensions: metals like platinum and silver when pulverised by the electric arc; finely crushed minerals like quartz, alumina, kaolin; completely insoluble chemical precipitates like the sulphides, notably nickel sulphide; or finally the iron tannate used in the manufacture of ink.

But, is there cause to give a particular name to bodies, the only singular properties—terribly commonplace properties—of which so far are insolubility and fineness?

These very minute bodies possess one quite special and very important property, however, which entitles them to being classed separately, that is the property of absorbing (by snobbery one prefers to speak of *adsorbing* nowadays) the soluble bodies which are held in solution by the liquid with which they are wetted. This absorption, which is frequent with chemical precipitates, is a very grave source of error in analyses. It is true that this property does not strictly characterise finely divided bodies; it manifests itself in identically the same way in porous bodies. Blood carbon, a true colloid, and wood charcoal behave in the same way. From this point of view, colloids and porous bodies must be classed together.

This absorptive power is a particular case of much more general properties which all very fine bodies possess. Chemically a body in the form of an impalpable powder behaves quite differently from the same body in the form of big lumps. There is a special chemistry of colloids and porous bodies. These particular properties are under the immediate sway of surface tension.

The fact has long since been acknowledged that all chemical phenomena depend directly upon diverse forms of energy: heat, electricity, work. The chemical reactions of combustibles liberate heat; the reactions of batteries generate electricity; the reactions of explosives, work. Reciprocally the forces of energy—temperature, electromotive force, pressure—define equilibrium conditions and suppress or attenuate at the same time passive resistances which oppose the reactions, tending to bring the bodies back to the state of equilibrium. The whole chemistry is only a chapter of energetics.

There is, however, one form of energy of which chemistry does not speak as a rule, that is the surface energy which is measured by the product of the surface tension (or capillary tension) and of the free surface of the body. In magnitude surface tension is generally infinitely small when compared with the other forms of energy. Take the gram-molecule of water, 18 grms., and assume it to have the form of a sphere whose diameter will be 3·3 cm. In contact with its water vapour the sphere will have a surface tension of 0·08 grm. per linear centimetre. The surface of the sphere being 34 sq. cm., its surface energy will be $0{\cdot}08 \times 34 = 2{\cdot}72$ grm.-cm., or $2{\cdot}72 \times 10^{-5}$ kg. m., which corresponds to $6{\cdot}3 \times 10^{-8}$ kg. calorie. Now the vaporisation of a grm.-molecule of water absorbs 10 calories, and its combination with lime liberates 10 calories. Its surface energy is therefore only equivalent to the one hundred-millionth part of that quantity of heat, that is to say, absolutely negligible.

If instead of taking the water in the form of a single sphere we divided it into a vast number of little globules, each of one-millionth of 1 mm., their surfaces and consequently their total superficial energy would become 330 million times greater, and thus equivalent to 2 calories; that is to say, the surface energy would be of the order of magnitude of the quantity of heat which water evolves in its various chemical reactions. The surface energy in that case would no longer be a negligible factor.

As regards solids in suspension in a liquid, there is no direct method for measuring the surface tension at the constant between the solid and liquid. Certain indirect considerations lead us to admit, however, that this tension may become a hundred times greater than that of water. The superficial energy will be increased in the same ratio and its influence will become appreciable for dimensions of the order of a ten-thousandth millimetre—dimensions much superior to those of chemical precipitates.

So far our considerations concern solely the grain size without paying attention to the greater or smaller solubility of the bodies in question. The considerations yet furnish the immediate explication of the usual insolubility of the colloids. A solid crystal ground down to very fine grains will certainly have all the properties of colloids, as long as it retains its fineness; but it will rapidly lose the latter as soon as it is brought in contact with a liquid capable of partially dissolving the substance. The energy of dissolution will be increased by the whole superficial energy of the crystal; there will result an increase in the solubility of the fine crystals, and a supersaturated solution will be produced, from which larger crystals will soon be separated. This fact has very clearly been verified for very fine precipitates of calcium sulphate and barium sulphate. In order to make these precipitates coarser, and thus to prevent them from passing through the filters, such precipitates are kept hot for several hours before filtration.

* A contribution to a General Discussion on "The Setting of Cements and Plasters," held by the Faraday Society, January 14, 1918.

Every soluble body, even if existing in very fine division, progressively loses its colloidal properties when it is maintained in contact with a liquid in which it is somewhat soluble; its transformation will be all the more rapid the greater the solubility. It is only insoluble bodies, therefore, which can preserve the extreme state of subdivision which corresponds to the colloidal state. For the same reason, bodies which are properly called colloids never show any discernible crystalline form, because the crystalline orientation supposes a certain mobility of the material within the solvent, be it liquid or gaseous.

We come to the hydraulic mortars. Are the products of their hardening colloidal or are they not? Let us first take the case of plaster. When plaster has set, we can never discern any crystals in the material, even under the strongest magnification of the microscope. That does not prove that no crystals are formed; perhaps they are too small to be recognised. In petrographic specimens, plates less than 0·02 mm. in thickness, one can hardly distinguish crystals less than 0·005 mm. in diameter. By crushing the soft mass under the cover-glass we cannot get below 0·0005 mm. We are thus yet far away from colloidal dimensions. When the humid hydrated plaster is left to itself, crystals begin to become discernible at the end of several weeks; after several years they are sometimes visible to the naked eye. One can see them plainly, in the south of Algeria, on the roots of dead trees which have been transformed into gypsum. We can, moreover, make the crystals in hardening plaster visible from the beginning, when we gauge the plaster with alcoholic water (instead of pure water); the setting is then retarded and the crystals can better develop.

The calcium aluminates, which play an important part in the hardening of rapidly setting cements, are hydrated at the same rate as the plaster, and they give likewise a whitish mass in which crystals are not discernible. If, instead of gauging the aluminate with little water, we put a few isolated grains of the aluminate into a large volume of water, we observe that the grains soon become surrounded by long crystals of hydrated aluminate, which are always easily visible under the microscope and can sometimes directly be seen by the eye.

Calcium silicate alone causes a difficulty in these considerations, and this is important, because the silicate is the essential element in the hardening of Portland cement. The microscope has never enabled us to see hydrated calcium silicate. Its crystals are certainly very minute; numerous analogies prevent us, however, from denying their existence. The hydration is exactly the same as in the case of barium silicate.

$$SiO_2.3CaO + aq. = SiO_2.CaO,aq. + 2CaO,H_2O.$$
$$SiO_2.2BaO + aq. = SiO_2\ BaO,6H_2O + BaO,9H_2O.$$

The crystals of hydrated lime are plainly visible, like those of hydrated baryta; they may attain dimensions of several mm. Crystals of barium silicate can always be seen with the aid of a lens, sometimes even with the naked eye. By virtue of analogy we may say that hydrated calcium silicate will certainly crystallise as well; but as it is much less soluble than the barium compounds, the crystals will be too minute to be discernible.

It is not impossible that, initially, the dimensions of these crystals are of colloidal order, as in the moment of formation of the precipitates of barium sulphate and calcium oxalate. I have shown, in fact, that this calcium silicate precipitate absorbs, in the moment of its formation, a certain quantity of lime which varies with the concentration of the liquid. In the course of time the dimensions of the crystals must increase considerably, as in all similar instances. The mechanical resistance does not diminish with time, quite on the contrary. Consequently the colloidal state, which was possible at the beginning, has nothing to do with the hardening of the cement.

To come to an end, I will recall the explanation of the hardening of cements which I gave thirty years ago, and which does not appear to have been weakened yet.

The anhydrous compounds of cements, not being in chemical equilibrium when in contact with water, are more soluble than the same hydrated compounds. For this reason they give rise to the formation of a supersaturated solution from which the hydrated compound may rapidly crystallise. The liquid, being no longer saturated, can redissolve more of the anhydrous compounds, and the whole mass can thus crystallise progressively by passing through a stage of transitory dissolution in a limited volume of water, which, at any given moment, cannot maintain in solution more than a small portion of the total mass of salts present. The crystals which are deposited from the supersaturated solutions always appear in the shape of extremely elongated needles, which have the tendency to group themselves in spherolites about certain centres of crystallisation. The entanglement of all these crystals is the only cause of the solidity of the mass. They become welded with one another when the reciprocal orientation is suitable; they adhere by simple contact, as do all solid bodies when really resting upon one another. Finally, friction at the points of contact, even in the absence of all adhesion, suffices to produce a great strength of mechanical resistance, such as is found in all tissues and fabrics whose solidity has no other origin. The finer and the more elongated the crystals, the more numerous the points of contact and the greater the frictional resistance. The greater the area of contact, the more developed the adhesion. The progressive growth of the crystal dimensions by the mechanism which I have suggested increases the part played by adhesion while diminishing that due to friction. A material built up of very wide strips could be very solid if the strips were glued together at their contact surfaces.

THE EFFECT OF THE ADDITION OF SUITABLE SLAG ON THE SETTING PROPERTIES OF PORTLAND CEMENT.*

By E. DENY, I.A.M. (Ghent) and E. H. LEWIS, M.A.

We regret that we are not able to communicate results of laboratory research into the setting of Portland cement. Such research it has been impossible for us to undertake in these difficult times. For the last three years we have been responsible for the completion and starting of a plant, which at the outbreak of war was in course of erection, and for the manufacture of cement which in Germany would be called Eisen Portland. With a depleted staff it has been necessary to concentrate as far as possible on the actual production of cement. Research into this subject has been carried out with great thoroughness by Dr. Passow, whose work on it is well known, and by others. In this country very little research appears to have been done in connection with this class of cement, and we propose only to give certain results which have been obtained in the manufacture of such cement on an industrial scale. These, as far as they go, confirm the results given in Dr. Passow's "Die Hochofenschlacke in der Zementindustrie."

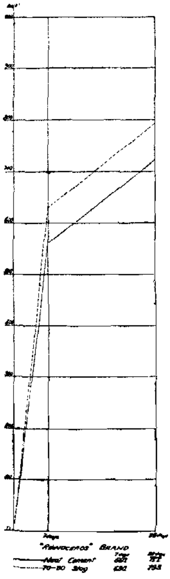
The slag which we have used comes from blast furnaces in which hematite pig iron is manufactured. It is therefore fairly high in lime, which runs approximately to 49 per cent, the silica being in the neighbourhood of 31 per cent and the alumina of 15 per cent. It is well known that in the manufacture of hematite pig iron the high lime content is due to the necessity of removing the sulphur from the metal. This sulphur is to some extent removed from the slag in the process of granulation, and the remainder is eliminated in the rotary kiln, so that there is no difficulty in keeping the sulphur content of the resulting cement within the limits of the British Standard Specification, even

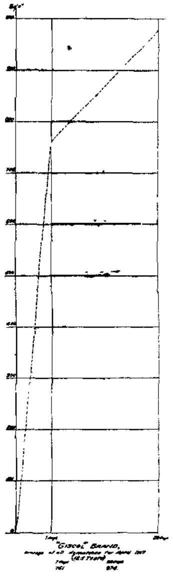
* A contribution to a General Discussion on "The Setting of Cements and Plasters," held by the Faraday Society, January 14, 1918.

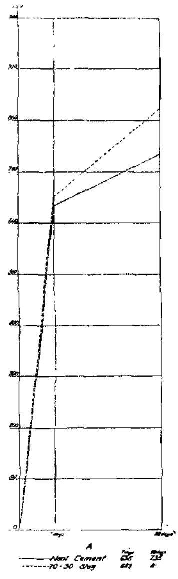
though the addition of gypsum or plaster of Paris be necessary to control the setting time,

The cement made from blast furnace slag is of course, like other Portland cement, made from limestone and clay. But a portion of the limestone and the bulk of the clay are subject to a double burning, being first passed though the blast furnace. Ninety per cent of the lime in the slag comes from the limestone used as flux in the furnaces, while roughly 70 per cent of the silica comes from the ores and 70 per cent of the alumina from the coal used in Scottish practice.

The splint coal commonly used in Scottish furnaces contains approximately 2¼ per cent of alumina, due mainly to the inclusion of a certain amount of clay from the pavement or roof of the seams. Cement clinker made from such slag and limestone, on account of its comparatively high alumina-to-silica ratio, gives generally a quick-setting cement. But this property is capable of adjustment by the use of a suitable limestone, and by the addition of properly granulated slag. By these two expedients the setting time can, if required, be reduced to that of a medium or slow-setting cement. By those who are not familiar with the use of cement made in this way considerable objection is sometimes raised to the addition of granulated slag to the clinker in the finishing mills. Our experience is that such an addition of slag, up to 30 per cent of the total, not only regulates the setting time of the cement, but adds considerably to its tensile strength. Table I. shows the average of the tests taken from all the wagons of cement which have been sent out from the works since the commencement of manufacture.







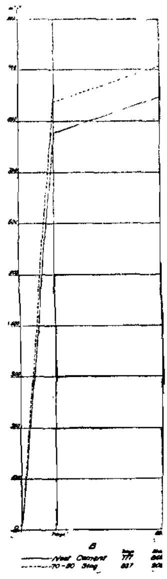


TABLE I. — *Tests of Cement Dispatched from Commencement of Manufacture to October, 1917—Average of 1711 Tensile Tests.*

	Lbs per sq. inch.
3 days	540
7 days	704
28 days	835

Not only is this improvement possible to the high alumina cement made from clinker, of which such slag and limestone are the constituents, but the effect is the same in the case of Portland cement made from the usual material. In the discussion which followed upon a paper read by Mr. B. J. Day at the Institution of Engineers and Shipbuilders in Scotland, on December 21, 1915, it was stated by a very competent authority that "German Eisen Portland cement was merely a genuine Portland cement adulterated with slag." This statement led us to make experiments to determine the result of adding granulated slag to a standard brand of Portland cement.

The granulated slag which we use has itself well-marked setting properties, as Table II. shows. It will be noticed that this slag, though high in alumina, gives a slow setting and hardening time.

Analysis of Slag.

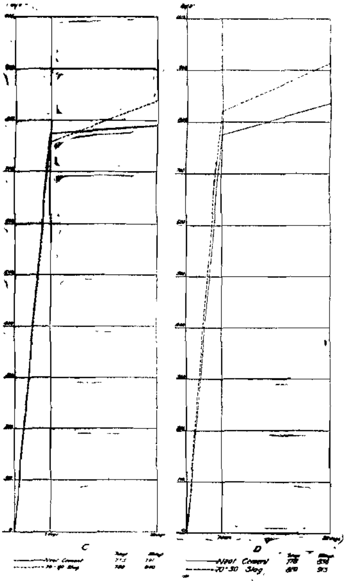
Silica	30·5
Iron oxide and alumina	16·6
Lime	49·4
Magnesia	2·3

TABLE II.—*Test of Briquettes made with Granulated Blast-furnace Slag, September 29, 1915 (Stored in Air).*

Tensile strength.	Lbs. per sq. inch.
3 days	195
7 days	300
28 days	430
2 months	480
4 months	480
6 months	615
12 months	470
18 months	528
24 months	666

TABLE III.—*Tensile Strength of Briquettes Gauged of 1 Slag, 3 Sand, 8½ per cent Water (Stored in Water).*

	Lbs. per sq. inch.
7 days	215
28 days	342
3 months	400



The results of tests made with the cement neat and with the cement mixed in the proportion of 70 to 30 with Wishaw blast furnace granulated slag are given in Table IV.

TABLE IV.

	Neat cement.	70 per cent cement plus 30 per cent slag.
Fineness—residue on 180 x 180 ..	10	10 (slag)
Setting time—initial	6 mins.	16½ mins.
„ final	8 mins.	1 hr. 10 mins.
Le Chatelier test—mm. expansion	3	1
Tensile strength—7 days	960	690
„ 28 days	722	793

The results of this experiment were so interesting that similar experiments were made with various other well known brands from England and South Wales, of which the results are given in Table V.

TABLE V.

	Neat cement.	70 per cent cement plus 30 per cent slag.
A		
Fineness—residue on 180 x 180	5·8 per cent	8 per cent (slag)
Setting time—initial ..	20 mins.	1 hour
„ final ..	5 hrs. 30 mins.	7 hours
Le Chatelier test—mm. expansion	1	1
Tensile strength—7 days	635	653
„ 28 days	735	823
B		
Fineness—residue on 180 x 180	10·8 per cent	7 per cent (slag)
Setting time—initial ..	50 mins	3 hours
„ final ..	1 hr. 40 mins.	5 hours
Le Chatelier test—mm. expansion	1	½
Tensile strength—7 days	777	837
„ 28 days	846	906
C		
Fineness—residue on 180 x 180	10·5 per cent	7·5 per cent (slag)
Setting time—initial ..	2 hours	2 hrs. 5 mins.
„ final ..	4 hrs. 10 mins.	3 hrs. 50 mins.
Le Chatelier test—mm. expansion	—	
Tensile strength—7 days	775	758
„ 28 days	791	840
D		
Fineness—residue on 180 x 180	12·7 per cent	–
Setting time—initial ..	4 hrs. 40 mins.	7 hrs. 30 mins.
„ final ..	6 hrs. 40 mins.	9 hrs. 20 mins.
Le Chatelier test—mm. expansion	1	1
Tensile strength—7 days	778	820
„ 28 days	836	913

There is one very interesting point to which we particularly wish to call attention. It is generally admitted that quick-setting Portland cement has less strength after a lapse of time than cement which sets more slowly.

With our cement the high content of alumina makes it possible, contrary to the generally accepted theory, to use without fear of expansion a greater percentage of lime in the clinker than is usual. The result of grinding such a clinker without any addition of raw slag is a very quick-setting cement; but if suitable slag be added such clinker gives a cement of reasonable setting time, which soon attains so great a strength that it has reached 1300 lbs. per square inch at twenty-eight days.

The result is, in our opinion, due to the presence in the clinker of a large proportion of "alite," consequent upon the high percentage of lime, which is greater than could be carried in ordinary Portland cement.

We venture to suggest the explanation that this quick setting and quick hardening are due to the colloid, which is first formed by the hydrolysis of the aluminate of lime, and is present to an unusual degree, having a favourable influence upon the subsequent formation of a colloid by the hydrolysis of the silicate of lime. This would corroborate the theory of Dr. W. Michaëlis on the phenomenon of the setting and hardening of cements. It would be of great interest if further research could be carried out upon this point, which is peculiar to cement made in the way we have described.

THE ORES OF COPPER, LEAD, GOLD, AND SILVER.

By CHARLES H. FULTON.

(Concluded from p. 82).

Gold Ores.

Gold Practically Free, associated with some Sulphide, Gangue, Quartz, or Siliceous Rocks.

Homestake Mine, S. Dak.—The ore body worked by the Homestake Mine, S. Dak., lies in a mineralised zone of slates and schists. The ore consists chiefly of chlorite, ferruginous hornblende (cummingtonite), and quartz, small amounts of garnet, mica, and carbonates of lime, and magnesia and iron as gangue, through which is disseminated pyrite, pyrrhotite, arsenopyrite, and gold largely in the free state. Unoxidised ore has the following composition:—Silica, 54 per cent; iron sulphides, 5·5 per cent; iron oxides, 18·7 per cent; alumina, 5·8 per cent; magnesia, 3·6 per cent; lime, 1·75 per cent; soda, 0·5 per cent; potash, 0·85 per cent; carbonic acid and water, 5·35 per cent. Oxidised surface ore has a similar composition, except that it contains little iron sulphide and more iron oxides and alumina. The average content of the ore in gold is a little less than 0·2 ounce per ton, equivalent to 4 dols. worth, of which 94 per cent is recovered. The gold is alloyed with silver to the extent of 5 parts gold to 1 of silver. It is treated by amalgamation to recover "free gold," after which it is cyanided. The Homestake Mine is probably to be considered the world's greatest gold mine.

The Rand, Transvaal, South Africa.—The Rand ores occur in a quartz pebble conglomerate which is interstratified with quartzites, sandstones, and schists. The conglomerate consists of rounded pebbles one-third of an inch to 6 inches in diameter, which are cemented together by a matrix of silica, iron oxide and pyrite, and chloritic matter. The gold, which occurs chiefly in the free state, is almost entirely in the cementing material and is closely associated with the pyrite. The ore consists essentially of silica, some iron oxide, and pyrite. The value of the gold in the ore is 7 to 10 dols. per ton. The gold is recovered by amalgamation and cyanidation, the recovery being about 90 per cent of the gold content. This is the world's greatest goldfield, the production in 1912 being 9,131,558 ounces (valued at 188,749,317 dols.), or 40 per cent of the world's production.

Douglas Island, Alaska.—The Douglas Island, Alaska (Treadwell mines), ore is an altered eruptive rock (albite-diorite) through which is scattered pyrite with some pyrrhotite and free gold. The principal gangue minerals composing the mass of the rock are felspar, calcite, and quartz, and through these are disseminated the sulphide minerals pyrite and pyrrhotite, with probably some arsenopyrite, constituting about 2 per cent of the ore. Some magnetite is also present. Stibnite, chalcopyrite, molybdenite, sphalerite, and galena are occasionally found, but are not of importance. The gold, although largely "free," is closely associated with the sulphides. The ore is milled by amalgamation and concentration, and the concentrate is cyanided. About 48 per cent of the gold is recovered by amalgamation, and 46 per cent by concentration and cyanidation. The average value of the ore is a few cents less than 2 dols. per ton. These ores are the lowest grade gold ores in the world successfully mined and milled at a profit, with the exception of those ores in some smaller mines, such as the Wasp No. 2, in the Black Hills of South Dakota.

Grass Valley, Nevada County, Cal.—The ore deposits in Grass Valley, Nevada County, Cal., are quartz veins in eruptive rock (grano-diorite). The ores consist essentially of quartz, through which is disseminated about 2 to 5 per cent of the sulphide minerals, chiefly pyrite, although small quantities of arsenopyrite, galena, chalcopyrite, and sphalerite are also found. The gold occurs chiefly in the free state, although part of it is intimately associated with the sulphides. The ores are treated by amalgamation and concentration; the concentrate is cyanided or smelted. The gold content of the ores differs at the several mines of the district. In the Grass Valley mines an average value is about 10 dols., whereas in the Nevada City mines it is somewhat lower.

Ores in which the Gold is partly Free but chiefly Associated with Iron Sulphide Minerals.

Ouray, Colo.—The ore deposit worked by the Camp Bird Mine, Ouray, Colo., is a vein in eruptive rock. The main gangue mineral is quartz, but calcite, rhodonite, and chlorite are also present. The sulphide minerals found, in order of their importance, are pyrite, galena, chalcopyrite, and sphalerite. Some magnetite is present. The gold is in part free and intimately associated with the magnetite and galena, and to a lesser extent with the pyrite. The silver present is associated with the galena. 96 per cent of the ore value is in gold. The gold, which occurs as a gold-silver alloy, is 740 fine; the remainder, 260 parts, is chiefly silver. The average composition of the ore as milled is as follows:—Silica, 85·20 per cent; galena, 0·50 per cent; chalcopyrite, 0·80 per cent; pyrite, 6·5 per cent; magnetite, 0·5 per cent; sphalerite, 3 per cent; rhodonite, 2·50 per cent; alumina, 1·50 per cent; the ore is milled by amalgamation, concentration, and cyanidation, and 95 per cent of the ore value is extracted. Of this, 64 per cent is recovered by amalgamation, 7 per cent by cyanidation, and 29 per cent by concentration. The concentrate, which is smelted, has the following analysis:—Gold, 2·21 ounces per ton; silver, 20·9 ounces per ton; lead, 9·8 per cent; copper, 2·4 per cent; silica, 12·8 per cent; iron and manganese, 20·9 per cent; lime, 3·8 per cent; zinc, 14·5 per cent; and sulphur. The value of the ore in 1911 was about 24 dols. per ton. The Camp Bird Mine works a high-grade ore, and although it is now nearing exhaustion, it was one of the great mines of the world.

Morro Velhoe Mine, Minas Geraes, Brazil.—The ore deposits of the Morro Velhoe Mine, Minas Garaes, Brazil, are veins in schistose rocks. The averag mineralogical composition of the ore is:—Pyrrhotite, 28· per cent; arsenopyrite, 5·04 per cent; pyrite, 2·5 pe cent; chalcopyrite, 0·66 per cent; quartz, 24·10 per cent siderite, dolomite, and calcite, 39·20 per cent. Th chemical analysis is:—Silica, 24·10 per cent; iron, 31·4 per cent; arsenic, 2·32 per cent; sulphur, 13·52 per cent alumina, 3 per cent; manganese dioxide, 1·30 per cent lime, 3·08 per cent; magnesia, 6·51 per cent; copper 0·21 per cent; carbon dioxide, &c., 14·49 per cent. Th ore is milled by amalgamation and concentration, th concentrate being treated by a special process at the mine The ore has a value of 10 to 15 dols. per ton, of whic about 70 per cent is recovered by amalgamation, and 10 t 12 per cent from the concentrate. The high percentag of sulphides in this ore is a noteworthy feature.

Ores containing Gold in Chemical Combination, chiefly as Tellurides.

Cripple Creek, Colo.—The Cripple Creek, Colo., o bodies are veins in eruptive rocks. The veins are narrov and the ore as mined contains considerable wall roc which may be either granite or phonolite. Aside from th included rock, the chief gangue minerals are quart fluorite, and dolomite. Gold occurs as the telluride calaverite, sylvanite, and krennerite, stated in order of the importance. With the tellurides are associated pyrite a sphalerite as the chief sulphide minerals, but they a probably not gold-bearing. Galena, stibnite, tetrahedrit and molybdenite in small amounts are found. The o contain a small quantity of silver, which is a constitue of the tellurides. The average chemical composition the ore is as follows:—Silica, 57 per cent; alumina,

* *Technical Paper* 143, Department of the Interior, U.S.A. Bureau

per cent; iron, 4 per cent; magnesia, 0·8 per cent; lime, 1·50 per cent; alkalis (soda and potash), 10·5 per cent; sulphur, 2·5 per cent; very small quantities of zinc, copper, arsenic, lead, and molybdenum. The grade of the ores varies much from high-grade smelting ore to low-grade milling ore. Old dumps containing ore valued at 3·50 to 3·80 dols. per ton are successfully treated by cyanidation. The average value of the ore mined in the district is probably about 19 dols. per ton. The Cripple Creek district is one of the world's great goldfields.

Goldfield, Nev.—The Goldfield, Nev., ore deposits are veins in eruptive rock (dacite). The ore is essentially a silicified dacite consisting of 50 to 75 per cent quartz; kaolinite and alunite (a hydrated sulphate of alumina and potassa), and 5 to 7 per cent of pyrite. Minerals present in small amount, but closely associated with the gold, are bismuthinite and tetrahedrite. A small amount of chalcopyrite is found. The gold occurs both free and closely associated with other minerals, and perhaps in the form of tellurides, possibly calaverite and other rarer telluride minerals. The gold is accompanied by some silver, the ratio being about 65 to 1. The following is a typical analysis of very high grade ore:—Silica, 77·08 per cent; alumina, 4·96 per cent; iron, 3·63 per cent; calcium, magnesium, and manganese oxides, 0·92 per cent; potassa, 1·42 per cent; soda, 3·22 per cent; copper, 0·37 per cent; bismuth, 1 per cent; tellurium, 0·14 per cent; sulphur, 4·80 per cent; gold, 131·24 ounces; and silver, 20·42 ounces per ton. Most of the ore of the district is treated by combined amalgamation, cyanidation, and concentration, the ore of the Goldfield Consolidated Mine, the largest producer of the district, having an average value of 19.77 dols. during 1912. Table VI. are analyses of typical higher grade ores as shipped to smelters.

TABLE VI.—*Analyses of Typical High-grade Ores from Goldfield Consolidated Mine.*

	Analysis No. 1.	Analysis No. 2.
Gold (ounces)	5·40	5·21
Silver (ounces) ..	34·61	5·42
Silica (per cent) ..	67·3	45·8
Iron (per cent)	3·4	5·6
Sulphur (per cent) ..	1·4	4·8

Kalgoorlie, Australia.—The Kalgoorlie, Australia, ore bodies are veins in chloritic schist. The gangue of the ore, aside from included country rock, is chiefly quartz, calcite, siderite, and dolomite, through which is scattered considerable pyrite. The gold occurs chiefly as the tellurides, calaverite, sylvanite, and petzite, but some free gold is found. Some telluride of mercury occurs. The following analysis represents typical ore:—Silica, 60·6 per cent; alumina, 5·75 per cent; pyrite, 5·32 per cent; carbonate of lime, 11·19 per cent; carbonate of magnesia, ·29 per cent; carbonate of iron, 10·23 per cent; alkalis (by difference), 1·62 per cent. The value of the ore varies from about 7 to 17 dols. per ton at the different mines, with an average value of about 10 to 11 dols. for the district. The ores are treated by cyanidation. This district is the great goldfield of Australia.

Gold-silver Ores.

(Both silver and gold present in considerable amount).

Liberty Bell Mine, Colo.—The ore body worked by the Liberty Bell Mine, Colo., is a vein in eruptive rock (andesitic breccia). The mineralogical composition of the ore is as follows:—Quartz and clay, 84·44 per cent; calcite, 9·45 per cent; apatite, 0·20 per cent; pyrite, 3·60 per cent; arsenopyrite, 0·24 per cent; bornite and chalcopyrite, 0·15 to 0·23 per cent; some manganese oxides. The gold occurs free and closely associated with sulphides. The silver is present as argentite, and as free silver and in more complex mineral form. Galena, sphalerite, and tetrahedrite occur only occasionally. The value of the ore is about 8.35 dols. per ton, the ore containing 0·31 ounce of gold and 3·45 ounces of silver per ton. The ore is treated by amalgamation, concentration, and cyanidation. Typical concentrate has the following analysis:—Gold, 1·43 ounces per ton; silver, 28·8 ounces per ton; silica, 9·4 per cent; iron and manganese, 38·8 per cent; lime, 1 per cent; zinc, 2·6 per cent; sulphur, 31·2 per cent.

Las Dos Estrellas, near El Oro, Mexico.—The ore bodies at Las Dos Estrellas, near El Oro, Mexico, are veins in shales associated with eruptive (andesite). The ores milled are both oxidised and unoxidised, and consist of quartz, altered shale, and andesite. In the unoxidised ores considerable pyrite is present. The gold occurs in the free state, but very finely divided; the silver occurs as argentite in the sulphide ores, and as chloride and metallic silver in the oxidised ores. Zinc, lead, and copper minerals are practically absent. The ore as mined contains about 0·4 ounce of gold and 7 to 8 ounces of silver per ton. It is treated by cyanidation. The mines in the vicinity of El Oro are among the most important mines in Mexico, and rank with the world's greatest gold mines.

Silver Ores.

Ores containing chiefly Native Silver.

Batopilas, Mexico.—The Batopilas, Mexico, ore deposits are veins in eruptive rock (diorite). The ore is essentially native silver in calcite as a gangue mineral. The silver in the low grade ores is very finely disseminated throughout the gangue, most of it being of such fineness that it will pass a 40 to 60 mesh screen. Silver is found also in large masses, and is unusually pure. In the low-grade ores the native silver is associated with argentite, pyrite, galena, and sphalerite. Silver minerals such as cerargyrite were found only in the upper oxidised part of the vein. The low-grade ore and the tailings from rich ore are treated by concentration, amalgamation, and cyanidation.

Cobalt, Canada.—The Cobalt, Canada, ore bodies are veins in a complex of metamorphic rocks and Huronian conglomerate associated with an eruptive rock (diabase). The gangue of the ores is largely calcite, with fragments of wall rock and some quartz. The silver occurs chiefly as native silver, frequently in large masses and nuggets, but also in small grains, rather finely disseminated. Silver minerals, as dycrasite (antimonial silver, Ag_3Sb), argentite, and pyrargyrite, are also found, but are subordinate in importance. Associated with the silver are the minerals smaltite (cobalt nickel arsenide, $CoNiAs_2$) and niccolite (nickel arsenide, NiAs), and other cobalt nickel minerals. The nickel cobalt content of the ores is not as yet of much commercial importance, but will probably become so. The value of the ores varies much, as they range from high grade to medium grade. Ores containing more than 100 ounces of silver per ton are milled or shipped and smelted, and ores with a lower metal content are first concentrated. Typical shipping ore has the analyses given in Table VII.

TABLE VII.—*Analyses of Typical Shipping Ore from Deposits at Cobalt, Canada.*

	Analysis No. 1.	Analysis No. 2.
Silver, per ton (ounces)	630·3	187·6
Copper (per cent).. ..	0·1	0·1
Silica (per cent)	6·8	58·1
Iron (per cent)	7·8	6·2
Lime (per cent)	7·8	3·8
Arsenic (per cent).. ..	34·9	1·2
Sulphur (per cent) ..	2·4	4·0
Cobalt and nickel.. ..	Considerable	Considerable

The average silver content of concentrating ore in 1910 was about 27 ounces per ton. The concentrate is shipped, and the tailings from concentration at a number of mills are treated by cyanidation for a further recovery of silver. Cobalt is the world's greatest silver district.

Ores containing Silver chiefly as Argentite.

Pachuca, Mexico.—The Pachuca, Mexico, ore bodies are veins in eruptive rocks (andesite). The gangue of the

ores is essentially quartz, although in some mines of the district rhodonite is an important gangue mineral. Some clay occurs, and in places a little calcite. Practically all ores now mined are unoxidised. The sulphide minerals are present only in small amount, and consist of pyrite, a little galena, and chalcopyrite. The great Santa Gertrudis vein is remarkably free from sulphides other than argentite, the form in which practically all the silver occurs. The ratio of silver to gold is about 200 to 1 by weight. In some of the mines a little native silver is found with the argentite. Other silver minerals are comparatively rare. The ores of the Santa Gertrudis range in value from 10 to 20 dols. per ton. The Pachuca district is one of the great silver districts of Mexico. The ores are treated by cyanidation.

Chihuahua, Mexico.—The ore bodies at Chihuahua, Mexico (Palmerejo mines), are veins in eruptive rock. The gangue is largely siliceous, included rock and quartz with some oxide of manganese and calcite, through which is disseminated a small percentage of pyrite and the silver minerals. The chief silver mineral is argentite, though some stephanite and cerargyrite are present. Very small quantities of antimony, arsenic, bismuth, copper, and zinc are found. The ore contains about 4 dols. worth of gold and 30 ounces of silver per ton. It is treated by concentration and cyanidation.

Silver present in part as Complex Silver Minerals.
(Or associated with appreciable amounts of argentiferous galena or sphalerite).

Parral, Chihuahua, Mexico (Veta Colorado).—The ore bodies at Parral, Chihuahua, Mexico, are quartz veins in shale or limestone associated with eruptive rocks (quartz-andesite dikes). The gangue is quartz through which is disseminated 2 to 3 per cent of pyrite, and galena and zinc blende up to 1·5 per cent each, and the silver minerals, chiefly argentite, with a small amount of cerargyrite. A very small amount of copper is present. Gold is practically absent. The ore is treated by concentration and cyanidation.

Guanajuato, Mexico, (Veta Madre).—The ore body at Guanajuato, Mexico, is a large vein in a calcareous agglomerate and other detrital rocks, associated with eruptives (rhyolite, andesite, and granite). The gangue consists of quartz, some calcite, and fragments, of country rock cemented by silica, and impregnated with pyrrhotite and pyrite. The silver minerals are chiefly argentite, stephanite, and pyrargyrite, and some proustite and polybasite. Galena, chalcopyrite, and sphalerite are rarely found. The amount of gold is about 0·005 that of silver present, by weight. The analysis of the milling ore is as follows:—Insoluble (silica), 85 per cent; iron, 6 per cent; sulphur, 2·5 per cent; lime, 2 per cent. The ore contains about 14 ounces of silver and 0·06 ounce of gold per ton. It is treated by concentration and cyanidation. Guanajuato is one of the oldest silver-mining districts in Mexico, mining there having been begun shortly after the Spanish conquest. The district has produced enormous quantities of silver.

Tonopah, Nev.—The Tonopah, Nev., ore bodies are veins in an eruptive rock (andesite). The gangue of the ore consists chiefly of quartz, with adularia (potash felspar), muscovite, and a small amount of carbonates of lime and magnesia. The sulphide minerals are chiefly those of silver, argentite, polybasite, stephanite, and pyrargyrite. Pyrite is present only in very small amount. Galena, zinc blende, and chalcopyrite are found in insignificant quantities only. Selenium occurs in the ores, probably in part as a selenide of silver. The ratio of silver to gold by weight is 90 to 1. The average value of the ore is about 20 dols. per ton. The greater part of it is treated by concentration and cyanidation, and some of the higher grade ore is shipped to smelters. Typical analyses of smelting ore are given in Table VIII.

TABLE VIII.—*Typical Analyses of Smelting Ore from Tonopah, Nev.*

	Analysis No. 1.	Analysis No. 2.
Gold, per ton (ounces) ..	0·91	0·57
Silver, per ton (ounces)	88·17	58·21
Lead	None	None
Copper	None	None
Silica (per cent)	78·9	84·0
Iron (per cent)	1·8	1·8
Sulphur (per cent) ..	1·2	1·1

Aspen, Colo.—Certain mines at Aspen, Colo., produce a silver ore with a limestone gangue which has considerable value as a flux in lead smelting. Typical analyses of this ore are given in Table IX.

TABLE IX.—*Typical Analyses of Ore from Aspen, Colo.*

	Analysis No. 1.	Analysis No. 2
Gold	None	None
Silver, per ton (ounces) ..	7·4	7·1
Lead (per cent)	0·30	0·20
Copper	None	None
Silica (per cent	4·2	7·0
Iron and manganese (per cent)	1·3	1·7
Lime (per cent)	43·4	37·9
Zinc (per cent)	0·3	0·6
Sulphur (per cent)	0·8	0·6

Creede, Colo.—The Commodore Mine at Creede, Colo., produces a highly siliceous silver ore containing some lead that is useful to the lead smelter in concentrating lead-copper matte. The following is a typical analysis of this ore:—Gold 0·02 ounce and silver 23·5 ounces per ton; lead, 2 per cent; copper, none; insoluble, 82·6 per cent; true silica, 71·8 per cent; iron and manganese, 4·2 per cent; lime, 0·3 per cent; zinc, 0·3 per cent; sulphur, 2·1 per cent.

COPPER SULPHATE.

THE Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm Regulations, and of all other powers enabling him hereby Orders as follows:—

1. For the purposes of this Order the maximum prices for sulphate of copper shall be as follows:—

(*a*) In the case of sales for delivery free on rail, cart, barge, or ship, a maker's works or nearest siding or railway station, or nearest available wharf, the prices specified in the first schedule, hereto according to the date on which, under the terms of the contract for sale, delivery is to be made.

(*b*) *In the case of sales for delivery to consumer's* premises or nearest station, siding, or wharf direct from maker's works the maximum prices under paragraph (*a*) above plus all costs of transport from makers' works to place of delivery, excepting that where transport is partly by rail or water, no charge is to be made for cost of cartage or haulage by road from makers' works to railway station, siding, or wharf. Any cartage or haulage to consumer's premises to be charged at local rates.

(*c*) In the case of sales for delivery *ex* vendor's store or shop or *ex* war house, railway goods yard, or public wharf, the prices specified in the second schedule hereto according to the quantity of sulphate of copper included in the sale and the date on which, under the terms of the contract of sale, delivery is to be made.

(*d*) *In the case of sales for delivery to consumer's* premises from vendor's store or shop, or from warehouse, railway goods yard, or public wharf, the maximum prices authorised under paragraph (*c*) above, plus all costs of transport from vendor's store or shop, or from warehouse, railway goods yard, or public wharf to consumer's

premises, any cartage or haulage by road to be charged at local rates.

2. The maximum prices fixed by this Order are not prompt cash prices for sulphate of copper in maker's or vendor's bags. Where credit is given to the purchaser a reasonable extra charge may be made, provided that the discount allowed for net prompt cash is quoted on the invoice, and is such as to bring the net prompt cash price within the maximum authorised. If purchaser's bags or other packages are used a reasonable allowance shall be made.

3. The maximum prices fixed by paragraphs (a) and (b) of Clause 1 of this Order shall not apply to any sale by a maker for delivery as mentioned in those paragraphs where the quantity of sulphate of copper included in the sale is less than 1 ton, and none of the provisions of this Order shall apply to any sale of sulphate of copper for export from the United Kingdom. Save as aforesaid no person shall as on and from the day following the date of this Order until further notice effect or offer to effect any sale or purchase of sulphate of copper for delivery previously to September 1, 1918, at a price exceeding that prescribed by this Order as the maximum price (having regard to quantity, packages, date for the terms of delivery) of such sale.

4. The maximum prices fixed by this Order are for sulphate of copper of standard quality; *i.e.*, of not less than 98 per cent purity, and as on and from the day following the date of this Order no person shall effect or offer to effect any sale or purchase of sulphate of copper of less than standard quality for delivery previously to September 1, 1918, except under and in accordance with the terms and provisions as to price or otherwise of a licence issued by or under the authority of the Minister of Munitions.

5. All persons engaged in producing, making, selling, distributing, or storing sulphate of copper shall make such returns with regard to their businesses, and shall verify the same in such manner (including production of their books to any accredited representatives of the Minister of Munitions) as shall from time to time be required by or under the authority of the Minister of Munitions.

6. For the purposes of this Order and the schedules hereto, sulphate of copper shall mean and include sulphate of copper, blue stone, and blue vitriol.

7. Nothing contained in this Order shall affect any Order heretofore or hereafter made by the Minister of Munitions with regard to copper.

8. This Order may be cited as the Copper Sulphate Order, 1918.

Note.—All applications in reference to this Order should be addressed to the Director of Acid Supplies, Ministry of Munitions, Department of Explosives Supply, Storey's Gate, Westminster, S.W. 1, and marked "Copper Sulphate."

First Schedule.

Date of delivery.	Price.
January-February, 1918	£48 per ton.
March-April, 1918..	£50 „
May-August inclusive, 1918 ..	£52 „

Second Schedule.

Quantity included in sale.	Date for delivery. Jan.-Feb.	March-April.	May-Aug. inc.
	Cwt.	Cwt.	Cwt.
2 cwt. and over..	54s.	55s.	56s.
56 lbs. and over, but less than 2 cwt.	56s.	57s.	58s.
28 „ „ „ 56 lbs.	58s.	59s.	60s.
	Lb.	Lb.	Lb.
8 „ „ „ 28 „	6½d.	7d.	7d.
4 „ „ „ 8 „	7d.	7½d.	8d.
1 „ „ „ 4 „	8d.	8½d.	9d.

Ministry of Munitions of War,
Whitehall Place, S.W.,
February 14, 1918.

NEW PATENTS AND DESIGNS BILL, 1917.

If ever there was a time when the Inventor should be encouraged it is now. It has often been said that this country owes it great industrial prosperity to its inventions and industries. The inventors of Great Britain have enabled British manufacturers to build up great industries which have been the envy of Germany.

When peace comes there will be the "after War" trade to consider and the restoration of our trade and industries, and, therefore, if we are to hold our own with other nations we must give every encouragement to our inventors. The inventor has in many ways suffered very severely from the conditions arising from the war. For instance, it has been impossible to manufacture, or to obtain the raw material to manufacture, patented articles for which orders have been obtained; while the sale of the patent rights is stopped owing to the knowledge that it is impossible to manufacture under the prevailing conditions, and to the restrictions applied to the flotation of new companies.

Messrs. Hughes and Young, Patent Agents, of Chancery Lane, London, write us that a Bill is now before Parliament purporting in one of its sections (7) to provide a remedy for the loss suffered by patentees from this cause, but from the views expressed by inventors in all parts of the country the Bill as it stands before Parliament does not in any adequate manner make provision for the recompense of the inventor of limited means who, owing to the war conditions, has been unable to reap the benefit from his patent which otherwise he would have realised.

It appears that the proceedings under the Bill now introduced will differ materially from those hitherto in vogue for prolonging the life of a patent. The Bill proposes that a patentee at the end of the term of his patent rights should appeal to the Court (an expensive procedure) for a prolongation of the patent, when proved hardships suffered by reason of the war should be held to be grounds justifying the grant of an extension of the patent.

This is no real remedy for many a poor inventor with an effective commercial invention at the outbreak of war. With his patent in the early years of its existence he had prospects of reaping a reward for his endeavours, and had in fact succeeded in placing his invention upon the market, after expending all his capital and a considerable amount of labour, and then owing to the difficulties of obtaining material found it impossible to execute the order or comply with contracts in hand. This has spelt ruin to him, and in consequence he has been obliged to abandon his patent without the slightest prospect of continuing it for the fourteen years and then finding funds for the prosecution of an appeal to the Court.

Messrs. Hughes and Young suggest that the Comptroller of the Patent Office should have power, in regard to cases in which he is satisfied that war conditions have been the actual cause of hardship of the above nature to the holder of a British Patent, to order that the period of time covered by the duration of the War should not count in the life of the Patent, and to waive the payment of any renewal fees falling due during such period. Any inventor who is affected should communicate with his Member of Parliament without loss of time.

Announcement.—Messrs. W. H. Smith and Son have been commissioned to distribute two million copies of the pamphlet "Murder Most Foul," which contains an Address delivered in Baltimore, U.S.A., by Dr. Dwight Hillis, after a visit to the western battle front. A knowledge of the dealings of the Hun with the villagers of Belgium should be spread to the most remote parts of our country, and Messrs. W. H. Smith and Son are doing a work of great national utility in arranging for the distribution of the pamphlet. It is to be hoped that its circulation in England will attract the same widespread interest as in America, where it was the means of first bringing home to many people the true nature of the Prussian,

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, January 31, 1918.

Sir J. J. Thomson, O.M., President, in the Chair.

Papers were read as follows:—

"*The Growth of Trees.*" By A. Mallock, F.R.S.

In this paper an account is is given of some recent observations of the growth of trees.

The observations consisted in the measurements, at short interval of time, of the variation of the girth of the trees at a height of four or five feet above the ground.

The measures were made by an "interference" method which is described.

The results showed a well-marked daily period in the variation of girth, different for different species of tree, but in all cases having a maximum at night and a minimum shortly after noon.

Diagrams of sets of observations, each extending over several days, are included, showing the growth of a black poplar, an oak, and a Douglas fir. From twenty to thirty readings were taken in the course of each twenty-four hours.

"*Action of Light Rays on Organic Compounds and the Photosynthesis of Organic from Inorganic Compounds in Presence of Inorganic Colloids.*" By Prof. B. Moore, D.Sc., F.R.S., and T. A. Webster.

The results are recorded under three sections:—(*a*) photosynthesis by inorganic transformers; (*b*) action of sunlight and of ultra-violet light upon concentrated solution of formaldehyde; (*c*) the general formation of formaldehyde by the action of light upon organic substances of biochemical origin.

In the first section the reactions of a number of inorganic systems in presence of carbon-dioxide and exposure to light are investigated, and it is shown that certain of these can build up formaldehyde while others are inert. The activity is shown to be related to the development of an optimum degree of colloidality, and is not due to formation of higher or lower oxides, but more probably to surface condensation on interfaces.

The second section deals with the condensation of formaldehyde to form reducing substances leading to carbohydrates, and discusses the conditions favourable for such condensations. The energetics of such a system are treated of in this section, and the effect of general or local concentration are considered. The equilibrium point in reversible reactions is shown to be dependent on concentration.

In the concluding section a general reversible reaction is described as a result of which formaldehyde rises in all intense reactions of light upon substances of bio-chemical origin. This reaction in presence of excess of light is an interesting reversal of the process by which all organic matter has been built up from inorganic sources.

The bearing of this process upon the germicidal action of sunlight, and the destruction of living organisms by ultra-violet light, is discussed, and it is pointed out that the simple organic products so formed are incompatible with the life-processes of living organisms and so lead to their destruction.

Taking such a reaction as travelling in the reverse direction, it is shown that the building up of organic matter from inorganic must have been a necessary precedent to any existence of living organisms on the earth, and that all accumulations of reduced substances possessing stores of chemical energy must have arisen in this manner from storage of the energy of sunlight.

"*Isolation and Serological Differentiation of* Bacillus Tetani. By Capt. W. J. Tulloch, R.A.M.C.

1. More than one variety of non toxic endsporing bacillus resembling *Bacillus tetani*, in morphological characters can be recovered from wound-exudates in cases of the disease.

2. There are at least three different types of toxic *B. tetani*.

3. The "U.S.A. type" of the bacillus—that commonly used for the preparation of antitoxin—is not frequently obtained from wound-exudates in cases of the disease occurring among men who have received prophylactic inoculations of antitetanic serum.

4. Culture in a selective medium followed by agglutination of the washed growth in presence of the three-type sera, gives valuable information. It is, however, apparently not so delicate a test for the presence of *B. tetani* as is animal inoculation after culture of the wound-exudate.

"*An Investigation into the Periodicity of Measles Epidemics in the Different Districts of London for the years* 1890-1912." By J. Brownlee, M.D.

This paper contains a continuation of the investigation of the periodicity of epidemics of measles in the city of London. The data investigated in this communication are the weekly number of deaths in certain different districts of London for the years 1890-1912. In the previous paper it was found that during these years the chief epidemic periodicities were respectively 87, 97, 109½, and 114 weeks, the most marked period being that of 97 weeks. It is found now that the epidemic with the 87 weeks period occurs solely south of the Thames, where it is a very marked phenomenon; that the epidemic with the 97 weeks period, while very marked in the whole of London, is especially marked in the western district; that the epidemic with the 109½ weeks period is present throughout London with the exception of the east, but is most marked in the western districts, while that with the 114 weeks period is most marked in the central districts and least present in the eastern districts. The most important fact, however, found is that the epidemics of different periods have special phenomena of their own. In the case of the chief period, that of 97 weeks, the epidemic practically breaks out synchronously in the whole city. In the case of the epidemic with the 87 weeks period a quite different phenomenon is found, the permanent seat of this epidemic being St. Saviours or Bermondsey, from whence the disease spreads to the neighbouring districts. With regard to the period 109½ weeks, there is evidence that in both the conditions just described exist, this epidemic breaking out synchronously in several districts and extending from these districts to neighbouring districts. The epidemic of 87 weeks throws some light upon the biology of epidemics. It is found as the epidemic extends from St. Saviour's peripherally that the date of the maximum of the epidemic becomes in each of these districts later in proportion to the distance traversed, and also, which is more important, that the number of the susceptible children affected becomes progressively less as the epidemic extends; in other words, this epidemic does not seem to die out from lack of susceptible persons, but because of loss of power of infectivity on the part of organism causing the epidemic.

PHYSICAL SOCIETY.

Ordinary Meeting, January 25, 1918.

The Presidential Address was delivered by Prof. C. V. Boys, F.R.S.

The exigencies of the war had seriously impeded the work of the Physical Society, as of all our scientific institutions. Many members were at the front; many others were busy on war work, and there was little time available for normal scientific pursuits. Since his predecessor's address the scientific community had been stirred to an extent which he thought was unnecessary by the passing of the Daylight Saving Act. Scientifically the thing was a sham, and as such was naturally distasteful to us; but the community at large was not scientific, and had a very vague notion of the meaning of time. In the stress of war

the public had realised the desirability of starting the day earlier to save not daylight but paraffin and gas, and the simple operation of putting all the clocks wrong, though hateful in principle, did not disturb the public at all.

In reference to the question of the metric system this was important in relation to education. He believed the reason why English schools were so backward in mathematics was that so much of the available time had to be devoted to memorising tables of weights and measures and similar medieval relics.

Another matter of public importance was the recognition of science as an element of general education. It is sometimes urged that our officials need not be scientific, because they can get all the scientific advice they want. But they may not know when they require it, or appreciate the force of it when they get it. He might instance in this connection the wasteful method of street darkening which still prevails after three years. The annual trouble with frozen water pipes was another example of the general ignorance of scientific principles. Burst pipes were unknown in really cold countries, where the elements of common sense were allowed to prevail.

All his own contributions to physical science had been experimental, and some words on the art of experiment might not be out of place. In order to succeed as an experimentalist it was necessary to find by personal experience how as many materials as possible behave under as many conditions as possible, and this can only be done by one who will practise every art and use every tool and instrument that he can. While endeavouring at first to imitate the practices of the professional mechanic and acquire as much of his skill as possible, the experimentalist must not be bound by tradition and custom in his methods. It is the slavery to tradition and practice that makes the assistance of the professional so tiresome to the experimentalist. In this connection a saying of Fresnel had greatly impressed him—"If you cannot saw with a file and file with a saw you will be no use as an experimentalist," or words to that effect. He had made it his business to use every tool and to handle every material that he could. On one occasion he had had the somewhat rare opportunity of handling five or six large uncut diamonds, each as big as a walnut. Glass blowers are familiar with the difference in the contact of freshly blown bulbs and of bulbs some time blown; but the contact of diamonds was unlike either. When brought lightly into contact they emit a curious squeaking note of possibly 2000 vibrations per second. This meant that the diamonds were bouncing with slowly diminishing excursions of 1/80,000 of an inch approximately, a phenomenon only possible with a material of such perfect elasticity or hardness. It was possible that a test of this kind might be useful for discriminating between the hardness of the harder materials. The whole question of what hardness was, and if, indeed, it were really a definable quantity having definite dimensions, was one to which the attention of physicists could profitably be diverted. Another such question was that of the oiliness of lubricants. This appeared to depend on something other than viscosity. Animal and vegetable oils lubricated better than mineral oils of the same viscosity.

A vote of thanks to the President for his Address was moved by Dr. C. Chree and seconded by Principal Skinner.

RÖNTGEN SOCIETY.

At the meeting of the Society, held on February 5, Dr. Batten read a paper on "*A Simple Means of obtaining Static Currents from an Induction Coil.*" The method consists in connecting one secondary pole of the coil to earth, whilst the other is connected through a series spark gap, oscilloscope tube, and a series condenser to the patient, who is placed on an insulated stand. The function of the condenser would appear to be that of a high resistance. The advantages of the apparatus are two-fold. In the first place, it overcomes the troubles due to a wet climate, from which the static machine always suffers; and secondly, it affords an inexpensive means, to those already possessing an induction coil, of obtaining currents similar to those produced by static machines.

Mr. E. E. Burnside read a paper describing a new Mobile Snook Apparatus. This is constructed on the same principle as the larger pattern hitherto in use, but is made in a more compact form by reducing the maximum spark gap to 7 inches.

Mr. Burnside also showed a small transformer constructed for employing the continuous current main supply to heat the spiral of the Coolidge tube. A small rotary converter changes the direct current into alternating current, which is stopped down to 12 volts by the static transformer. The secondary is well insulated from the rest of the apparatus, and regulation of the filament current is obtained by a variable choke-coil in the primary circuit of the transformer.

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS.

Annual General Meeting, February 6, 1918.

Mr. George Embrey, President, in the Chair.

The President delivered his annual Address.

The following were elected as Officers and Council for the ensuing year:—

President—Samuel Rideal.

Past-Presidents—Serving on the Council—(Limited by the Society's Articles of Association to eight in number)—L. Archbutt, E. J. Bevan, A. Chaston Chapman, Bernard Dyer, G. Embrey, Otto Hehner, E. W. Voelcker, J. A. Voelcker.

Vice-Presidents—W. T. Burgess, J. T. Dunn, C. A. Hill.

Hon. Treasurer—Edward Hincks.

Acting Hon. Treasurer—E. W. Voelcker.

Hon. Secretaries—P. A. Ellis Richards, E. Richards Bolton.

Other Members of Council—W. J. A. Butterfield, T. W. Glass, D. Lloyd Howard, G. N. Huntly, P. H. Kirkaldy, W. Partridge, W. H. Roberts, E. Russell, W. H. Simmons, G. Rudd Thompson, J. F. Tocher, J. Webster.

Ordinary Meeting, February 6, 1918.

Dr. S. Rideal, President, in the Chair.

A Certificate was read for the first time in favour of Mr. William Herbert Miles.

A Certificate was read for the second time in favour of Mr. Tom. M. McKenzie.

Messrs. Kendall Colin Browning, M.A., Frederick William Edwards, John Monteath Guthrie, Frederick Thomas Munton, Leonard Owen Newton, and Ernest Walter Wright, were elected Members of the Society.

The following papers were read:—

"*A Modified Acetic Acid Reagent for Valenta Tests.*" By A. E. Parkes, F.I.C.

A mixture of acids is recommended giving the same turbidity temperatures with fats and oils as pure acetic acid, and having the advantage of not solidifying in cold weather.

"*Oiticica Oil - a New Drying Oil.*" By E. Richards Bolton, F.I.C., and Cecil Revis, A.C.G.I., F.I.C.

The authors showed specimens of the kernels of *Couepia grandiflora*, and described the oil obtained therefrom, which has properties closely simulating those of Tung oil. Analytical figures for the oil were given, and various uses suggested, notably as a varnish oil.

FARADAY SOCIETY.

Ordinary Meeting, January 14, 1918.

A GENERAL Discussion on "*The Setting of Cements and Plaster*" was presided over by Mr. JAMES SWINBURNE, F.R.S., Past-President.

The CHAIRMAN said that it had been the intention of the Faraday Society to initiate a research on this important subject. This, however, was found to be impossible under the circumstances, and the present General Discussion was therefore arranged, in the hope that it would focus attention on existing gaps in our knowledge, and indicate fruitful lines of investigation, and so prepare the ground for the proposed research.

Dr. C. H. DESCH (University of Glasgow) opened the discussion with a paper on "*The Mechanism of the Setting Process in Plaster and Cement.*" (See p. 37).

Prof. HENRY LE CHATELIER (Paris) sent in a contribution to the discussion entitled "*Crystalloids against Colloids in the Theory of Cements.*" (See p. 85).

Prof. F. G. DONNAN, F.R.S., contributed a paper on "*The Agglomeration of Granular Masses,*" which in the absence of the author was communicated by the Secretary.

Attention is drawn to the four principal factors which tend to cause the caking, binding, or setting of granular materials, namely, the presence of unequally distributed stresses, of granules of unequal size, of unstable or metastable forms, and of sheared crystal faces. In all of these cases the material under one of the stated conditions is more soluble than the other form; thus solids under stress are more soluble than when unstressed, smaller granules than large granules, metastable than stable crystalline forms, and the amorphous surface of a sheared crystal possesses higher solubility than the stable crystalline surfaces. Hence, if the two forms exist side by side in contact with a solvent, the material will be dissolved from the one form and reprecipitated on to the other form, and so bridges of reprecipitated material will be produced, which will cement the separate particles into a compact mass. The operation of molecular forces under these conditions is fairly well understood, but it is not sufficiently known or appreciated by many occupied with industrial problems.

Mr. A. A. KLEIN (Worcester, Mass.) sent in a paper on "*The Constitution and Hydration of Portland Cement,*" which was read by Dr. C. H. Desch. (See p. 62).

A paper by Mr. G. A. RANKIN, of the Geophysical Laboratory, Washington, entitled "*The Setting and Hardening of Portland Cement,*" was read by Dr. C. H. Desch. (See p. 52).

Mr. JOHN RHODIN presented a "*Note on the Colloidal Theory of Setting.*" (See p. 39).

Mr. W. J. DIBDIN read a paper on "*Ancient and Modern Mortar.*" (See p. 61).

A paper by Mr. E. DENY, I.A.M. (Ghent), and Mr. E. H. LEWIS, M.A. (Wishaw), on "*The Effect of the Addition of Suitable Slag on the Setting Properties of Portland Cement*" was read by Mr. Lewis. (See p. 86).

Mr. BERTRAM BLOUNT read a paper on "*The Setting of Cement in its Relation to Engineering Structures.*" (See p. 51).

Mr. PERCY C. H. WEST also spoke on "*The Effect of the Addition of Slag to Portland Cement.*"

The origin of the discussion of this subject is to be found in the discovery of the cementitious properties of blast-furnace slag and the production of a pozzuolanic cement from this material.

Michaelis, and at about the same time Erdmenger, in the seventies and eighties observed the notable results obtained by the addition of pozzuolanic materials to Portland cement mortars, and these results were the first blows struck in a battle which is apparently not yet ended.

The publication of a circular by the "Vorwohler" Portland Cement Works, which were selling a Portland cement to which blast-furnace slag had been added, describing their cement as a "Portland cement improved by the addition of silica in an active form," was the next important incident in the conflict.

The Association of German Portland Cement Manufacturers then began to take active steps to show that such additions were adulterations and nothing more. Dyckerhoff was one of the strongest supporters of this view. On the other side was Dr. Passow.

The work carried out on an extensive scale by the Royal Prussian Material Testing Station generally agreed with the experience of the speaker, that while a Portland cement of relatively poor quality was often improved, a first-class Portland cement did not have its mechanical properties improved by such an addition. Yet he found that with such additions products could be obtained quite equal in mechanical properties to many Portland cements.

There was one point which had not been recognised, namely, the sensitiveness of Portland cements to which such additions had been made to sulphates contained in aggregates with which the cement was used. Tests which had been carried out by him showed that in cold, wet weather expansion of the concrete leading to most undesirable results was liable to occur where what may be described as an "Iron Portland Cement"—that is to say, a Portland cement to which slag had been added—was used; while, when Portland cement had been employed with the same aggregate and otherwise in similar conditions, such undesirable results did not occur.

The whole question had been energetically debated in the past, and for guidance in coming to a conclusion one must have regard to the prior publications concerning the matter.

The subject was then thrown open for general discussion.

Mr. W. D. CAROE gave some practical illustrations of the value of the scientific investigations into the problems connected with cements and mortars from the point of view of the builder. One case illustrated was the stability of St. Paul's Cathedral. Another case led him to question the wisdom of excluding clay from mortar, as was done in the standard specification adopted by architects. The expansion of cement containing slag needed investigation, as did also the chemical effect of cement on stone. As ordinarily used cement was often a source of great danger to old buildings.

Mr. A. BINNS spoke of the setting of cement from the point of view of the constructional engineer. Initial set must not take place until the material is in position, but once in place the setting and hardening should be rapid. He referred also to the improvements in cements during the last twenty years, largely due to scientific research. The percentage of water used in concrete was of great importance, and it was not sufficiently controlled.

Mr. W. J. COOPER considered that Portland cement as made to-day could be free from any danger of future expansion. Researches on the time of setting should be carried out with a view of improving setting qualities.

Dr. T. MARTIN LOWRY, F.R.S., spoke of the difficulties that often arose on account of the setting into a hard mass salts like ammonium nitrate. The fundamental cause was recrystallisation, but in the absence of moisture caking did not take place. Both caking and disintegration were broad, general phenomena, and further research was called for.

Mr. F. C. HEMMINGS thought that to explain the setting of plaster of Paris it was sufficient to assume that the dihydrate was deposited in the interstices of the tiny particles, and that the whole mass was not converted into dihydrate. In the case of crystalline salts the presence of a solvent medium was essential for setting. He gave some interesting details with regard to the conditions under which such setting took place, and also referred to some commercial applications of these problems.

Dr. W. Rosenhain, F.R.S., included the setting of metals in the more general analogous phenomena referred to by Dr. Donnan and the last speakers. Here also setting was caused by crystals adhering to one another very powerfully. The welding of metals was in that sense also a case of setting. He discussed the mechanism of crystal-adhesion, which was not due to frictional cohesion, and attributed it to a film of amorphous material between the crystals which, possessing the properties of undercooled liquid, had no planes of cleavage or weakness. The theory was borne out by what had been said about the setting of cements and of crystalline aggregates.

Dr. C. H. Desch summed up the results of the discussion. The differences between the crystalline and colloidal theories had been shown to be largely a difference in terms. The essential difference between cases of recrystallisation and of the setting of a colloidal mass lay in the solubility.

NOTICES OF BOOKS.

The Year Book of Pharmacy, 1917. London: J. and A. Churchill. Pp. 488. Price 10s.

The Year Book of Pharmacy for 1917 contains the usual full abstracts of original papers on pharmacy and chemistry published during the year. These are conveniently classified and well indexed. The complete lists of new remedies and new applications have been compiled for the Year Book by Mr. T. Stephenson, F.R.S.E. The research contains a large number of suggestions of subjects for investigation, and attention is called to the fact that a special fund exists to defray expenses connected with research work. The Executive Committee of the British Pharmaceutical Conference will be glad to receive applications from members for grants from this fund. The subjects include some which would probably require very extended investigation, while others might be elucidated quite quickly and comparatively easily; in all cases the results would be of great practical utility. A full report is given of the Conference held in July in London, and the Address of the President, Mr. C. A. Hill, on "Our Medicine Supply in War Time" is of great interest.

British Trade with Brazil. Hints for Manufacturers and Exporters. By Arthur Abbott, Secretary. Rio: Imprensa Ingleza. 1917. Pp. 30.

This report is issued with the authority of the British Chamber of Commerce in Brazil, and it is to be hoped that it will be widely circulated among merchants and manufacturers in the United Kingdom. The necessity for the adoption of the metric system of weights and measures is pointed out, and information is given as to the openings for retail stores, while detailed notes relating to the state of Brazilian trade in many commodities are provided. An important point to notice is the fact that representatives of British firms should have a good knowledge of the Portuguese language, not Spanish as is often supposed, and catalogues should be in the same language, and should contain full details, including prices. The Association of Chambers of Commerce of the United Kingdom, Parliament Mansions, Victoria Street, S.W., have had an edition of the pamphlet printed in England, and extra copies may be had from them.

Physical Society.—At the next meeting of the Society on Friday, February 22, 1918, at 5 p.m., at the Imperial College of Science, Imperial Institute Road, South Kensington, S.W., the following papers will be read:—"Note on the Use of Approximate Methods in obtaining Constructional Data for Telescopic Objectives," by T. Smith, B.A.; "A Suggestion as to the Origin of Spectral Series," by H. Stanley Allen, M.A., D.Sc.

CHEMCIAL NOTICES FROM FOREIGN SOURCES.

Note.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxv., No. 23, December 3, 1917.

New Fractionating Apparatus for Petrol and other Volatile Products.—E. Hildt.—The vapours are passed through six Vigreux columns in succession; these being heated externally by the vapour of a specimen of petrol boiling at a given temperature. Thus the vapours can be separated into fractions boiling at $>150°$, $130-150°$, $110-130°$, $90-110°$, $70-90°$, $50-70°$, $<50°$. In this apparatus the fractionation can be performed completely, and errors due to air currents are eliminated. Changes of atmospheric pressure do not affect the fractionation.

Bulletin de la Société Chimique de France. Vol. xxii., No. 10, 1917.

Ammonio Cobaltic Molybdate, Tungstate, and Vanadate; Separation and Estimation of Cobalt.—Adolphe Carnot.—With hydrogen peroxide and a fixed alkali cobalt gives sesquioxide, while nickel gives the protoxide. In a solution containing the two metals and an excess of ammonium chloride and free ammonia only the cobalt is peroxidised and forms an ammonio cobaltic salt, which can be precipitated by ammonium molybdate. In the cold the roseo cobaltic salt $[H_2OCo(NH_3)_5]Cl_3$ is first formed, but under the influence of ammonia and a moderate temperature it passes into the purpureo-cobaltic chloride. If it is heated still more the hexammonia salt is formed and some of the cobalt is precipitated as hydrate of sesquioxide. The luteo cobaltic chloride $Co(NH_3)_6Cl_3$ remains in solution. The two last chlorides can be used for the determination of cobalt by precipitation with ammonium molybdate. Tungstates and vanadates give the same reactions as molybdates with ammonio cobaltic solutions. Salts of nickel are not converted into peroxygenated salts and may thus be separated from cobalt.

Nitration of Benzoylformic Acid.—M. S. Reich and P. Morel.—When benzoyl formic acid is nitrated theoretically *m*-nitrobenzoylformic acid should be obtained, but the analogy of constitution between the group $O=C.COOH$ and $C\equiv COOH$ suggests the possibility of the NO_2 group taking the para or ortho position. This last supposition is not confirmed by experiment, however, the only product of nitration being *m*-nitrobenzoylformic acid.

MEETINGS FOR THE WEEK.

Monday, 25th.—Royal Society of Arts, 4.30. (Cantor Lecture). "The Economic Condition of the United Kingdom before the War—the Real Cost of the War—and Economic Re-construction," by Edgar Crammond.

Tuesday, 26th.—Royal Institution, 3. "A National Laboratory of Industrial Research," by Sir Richard T. Glazebrook.

Wednesday, 27th.—Royal Society of Arts, 4.30. "Organisation of Commercial Intelligence," by Sir William H. Clarke.

Thursday, 28th.—Royal Institution, 3. "Three French Moralists and their Influence on the War—Vauvenargues," by Edmund Gosse, C.B.

— Royal Society. "Scattering of Light by Dust-free Air, with Artificial Reproduction of the Blue Sky," by The Hon. R. J. Strutt. "The Lommel-Weber Ω Function and its application to the Problem of Electric Waves on a Thin Anchor Ring," by J. R. Airey. "Investigations on Textile Fibres," by W. Harrison. "Critical Loading of Struts and Structure," by W. L. Cowley and H. Levey.

Friday, March 1st.—Royal Institution, 5.30. "The Modern Dye-stuff Industry," by Prof. A. G. Green.

Saturday, 2nd.—Royal Institution, 3. "Problems in Atomic Structure," by Sir J. J. Thomson.

THE CHEMICAL NEWS.

VOL. CXVII., No. 3040.

A PERMANGANATE ELECTRIC CELL.

By ARTHUR W. WARRINGTON.

SINCE permanganic acid is a more powerful oxidising agent than chromic acid, it seems that a cell with the former as depolariser should be more active than one with the latter. Also there seems to be no adequate reason for taking strong solutions; on the contrary, everything appears against such a proceeding. Accepting the ionisation theory, the ions will be relatively more plentiful in a dilute solution than in a strong one.

The Two-Fluid Permanganate Cell.—A carbon plate was separated from a zinc plate by being placed in a porous jar. The capacity of the porous jar was about 250 cc., and that of the zinc compartment about 700 cc. 3·16 grms. of potassium permanganate and, probably, a little over 6 cc. of strong sulphuric acid diluted with water to 250 cc. were placed in the porous jar, and a strong solution of zinc sulphate in the outer compartment. The voltage of such a cell, measured with the only means at disposal, was about 2 volts.

Two such cells connected in series with a water voltameter and a tangent galvanometer were used in constant action for three hours and forty-six minutes, and the fall of current after the first ten minutes was from 0·09 ampere to 0·085. The experiment was divided into three periods, as the voltameter had to be refilled. During the first period 0·00361 grm. of hydrogen was evolved in 3855 secs., giving a current of 0·0895; during the second period 0·00368 grm. of hydrogen was evolved in 3975 secs., giving a current of 0·0886; during the third period 0·00368 grm. hydrogen was evolved in 4100 secs., giving a current of 0·0859 ampère. These figures are based on calculations made after the first 6 cc. had been evolved. As the platinum electrode was already grey with occluded hydrogen from previous experiments this precaution appeared sufficient. The current was also checked by readings of the tangent galvanometer, which had a constant of 0·150.

The readings of the galvanometer during the second and third periods were very constant. The highest reading in the second period was 30·65° and the lowest 30·25°. In the third period the highest reading was 29·9° and the lowest 29·4°.

It appears that a little over 6 cc. of strong acid should be added, though the writer's experience is that good results can be obtained with 6 cc. Two cells were made up, each containing, in the carbon compartment, 3·16 grms. potassium permanganate and 6 cc. strong acid, and 14·55 grms. crystallised zinc sulphate in the zinc compartment. The capacity of the carbon compartment was, as already stated, 250 cc., and that of the zinc compartment was about 700 cc. In series with a water voltameter and the tangent galvanometer they yielded the following results:—

Time in secs.	Unreduced volume of H.	Pressure.*	Temp.	Reduced volume of H.	Weight of H $\times 10^{-6}$.
398	5	720·2	12·4	4·53	407
818	10	722·9	—	9·10	816
1267	15	724·5	—	13·68	1227
1727	20	727·8	—	18·32	1640
2192	25	730·1	—	22·97	2061

Omitting the first 398 secs., and taking the weight of

Time in secs.	Weight of H $\times 10^{-6}$.	Current.	Tangent of galvanometer readings.	Current by galvanometer.
420	409	0·0934	0·610	0·0915
449	411	0·0877	0·595	0·0892
460	413	0·0859	0·585	0·0878
465	421	0·0865	0·577	0·0866

The voltage at the end of the experiment was about 3·7.

A bichromate cell with 5·88 grms. potassium bichromate and 13·72 grms. strong sulphuric acid in the carbon compartment, and strong zinc sulphate in the zinc compartment, was not nearly so efficient. Two such cells, connected in series with a water voltameter and a galvanometer, took 4965 secs. in liberating 0·00327 grm. of hydrogen, the average current being 0·0632 ampère. The galvanometer read 25·1° after the cells had been working for about ten minutes, and only 22° at the end of the experiment.

Single-Fluid Permanganate Cell.—The porous jar was removed from the cell used before, and the zinc well amalgamated. The capacity of the cell was now about 1000 cc. It was filled with an aqueous solution containing 3·16 grms. of potassium permanganate and 6 cc. of strong sulphuric acid. Two such cells connected in series with the water voltameter and the tangent galvanometer yielded 0·00415 grm. of hydrogen in 8780 secs. The current rapidly fell away. At the end of the first ten minutes it was 0·0538 ampere, and at the end of the experiment it was only 0·0358. The voltage of the two cells at the end of the experiment was about 3 volts.

The yield of electric current, by a two-fluid permanganate cell, becomes very high when the solutions used are very dilute. In the carbon compartment, of capacity 250 cc., was placed a solution containing 0·79 grm. of potassium permanganate and 1·5 cc. of strong sulphuric acid, containing about 2·64 grms. of acid. In the zinc compartment, of capacity 700 cc., was placed an aqueous solution containing 3·59 grms. of crystallised zinc sulphate. The cell was connected in series with a tangent galvanometer and a copper voltameter. The results are tabulated below.

Time in min.	Tangent of galvanometer readings.
0	1·61
10	1·257
20	1·199
30	1·118
40	1·043
50	0·985
60	0·931
70	0·884
80	0·842
90	0·803
100	0·763
110	0·733
120	0·706
130	0·681
140	0·663
150	0·640
160	0·622
170	0·608
180	0·588

Assuming that the constant of the galvanometer was $K = 0·150$, and applying Simpson's rule, the quantity of electricity yielded was

$$Q = 1/3 \times 10 \times 60 \times 46·572 \times 0·150$$
$$= 1397 \text{ coulombs.}$$

The weight of copper which should have been deposited was

$$W = 0·00032945 \times 1397$$
$$= 0·46 \text{ grm.}$$

The actual amount of copper deposited was 0·48. The difference between the calculated and the found was

galvanometer constant and the poorness of the balance. The galvanometer itself was a reasonably good one. The writer is waiting the arrival of better instruments, delayed by local disturbances, before making more than preliminary experiments.

Now this 0·48 grm. of copper must have required the presence of (0·48 × 98) / 63·6 = 0·74 grm. of sulphuric acid. The 1·5 cc. of acid actually used probably did not contain more than 2·64 grms. of pure acid. Hence, with a *considerable quantity of energy still available*, 28 per cent had already been yielded.

Chengtu, West China,
December 2, 1917.

THE RELATIVE STABILITY OF HALOGEN SUBSTITUTED ALIPHATIC ACIDS IN WATER SOLUTION.

By W. A. DRUSHEL and G. S. SIMPSON.

Among the investigators who have studied the stability of a few of the halogen substituted acids under various conditions are Buchanan (*Ber.*, 1871, iv., 863). Schwab (*Etudes de Dyn. Chem.*, 1884, p. 20), Wislicenus (*Ann.*, 1882, ccxii., 239), Kastle (*Am. Chem. Journ.*, 1892, xiv., 586; 1893, xv., 471), De Barr (*Am. Chem. Journ.*, 1899, xxii., 333), Bischoff (*Ber.*, 1899, xxxii., 1748), Lossen (*Ann.*, 1905, cccxlii., 112), Slator (*Trans. Chem. Soc.*, 1905, lxxxvii., 482; 1909, xcv., 93), Bevan (*Proc. Camb. Phil. Soc.*, 1906, xiii., 269), Senter (*Trans. Chem. Soc.*, 1907, xci., 466; 1909, xcv., 1827; 1911, xcix., 1049), Euler (*Ber.*, 1906, xxxix., 2726), Clark (*Trans. Chem. Soc.*, 1910, xcvii., 416), Madsen (*Trans. Chem. Soc.*, 1913, ciii., 965), and Johanssen (*Ber.*, 1915, xlviii., 1262). In general, the method of investigation has been to determine the rate of replacement of the halogen atom by certain groups. Since hydrolysis offers a method which is easy in manipulation, and which is not complicated by side reactions, it has been used by several investigators of this problem. This reaction in which the halogen atom is replaced by the hydroxyl group has been called hydroxylation by Frankland (*Trans. Chem. Soc.*, 1913, ciii., 713).

The most extensive work in this field has been done by De Barr and by Senter. De Barr has shown that many of these compounds are very stable toward water at the ordinary temperatures. In his experiments he found that secondary reactions accompanied the hydrolysis of several α-, β-, and γ-halogen substituted acids at 150°. Senter has conducted a series of important experiments in which he has studied the mechanism of the hydrolysis of the substituted aliphatic acids. Most of his work has been done on the α-brom substituted acids or their salts. He has shown that halogen acids act as negative catalysts. By means of a derived equation he has been able to determine the influence of this catalyst as the reaction progresses. The work of Johanssen is interesting because he has found a convenient method of making β-lactones which are intermediate products in the hydroxylation of β-substituted halogen acids under certain temperature conditions.

In this investigation we have studied the relative stability of several of the halogen substituted aliphatic acids. This paper includes only the work on halogen substituted acetic acids. In a later paper several substituted acids of the propionic and butyric series will be discussed. The work of De Barr has shown that it is impractical to hydrolyse the acids themselves, but Senter's experiments have suggested the possibility of using their sodium salts.

Preparation of Materials.

The chloroacetic, dichloroacetic, and trichloroacetic acids in stock were sufficiently pure for use in this investigation.

The bromoacetic ester was prepared by the method of Zelinsky (*Ber.*, 1887, xx., 2026). The bromoacetyl bromide was formed by treating glacial acetic acid with bromine in the presence of red phosphorus. This was converted to the ester by adding to chilled absolute alcohol. After washing, drying, and distilling the fraction boiling between 157—159° was considered sufficiently pure.

The iodoacetic acid was made from chloroacetic acid by boiling it in alcohol with an excess of potassium iodide, by the method of Abderhalden and Guggenheim (*Ber.*, 1909, xli., 2853).

The sodium salts of these acids were prepared by treating cooled alcoholic solutions of the free acids or their esters with the theoretical amount of strong sodium hydroxide solution free from carbonate. At this point in the process the sodium bromoacetate separated out pure from the alcoholic solution as described by Kastle (*Am. Chem. Journ.*, 1893, xv., 471). This salt was washed with chilled alcohol and ether, pressed on a porous plate, and dried in a desiccator. In all other cases it was necessary to evaporate the alcoholic solutions to a small volume at room temperature until the salt began to separate out, and then its separation was completed by chilling. The salt was filtered off, washed, and dried as described above. This method has the disadvantage that varying and undetermined amounts of water of crystallisation are not completely removed.

Procedure.

These salts were dissolved in water forming approximately 0·1 N solutions which were hydrolysed at 70° whenever convenient. In a few cases it was necessary to use a higher temperature due to the low velocity of the reaction at 70°. These values, determined experimentally at higher temperatures, were converted by means of the temperature coefficients to corresponding values for 70°. It will be shown in a later paper that in some cases secondary reactions disturb the main reaction at higher temperatures. In the work described in this paper, however, this discrepancy is negligible.

A thermostat with a bath of commercial paraffin was used and found satisfactory for several weeks at these high temperatures. The temperature of the bath was maintained constant within 0·01° by means of a mercury-steel regulator which was made by C. A. Kraus, of Clark University. (This regulator will be described in detail by Dr. Kraus in the near future). This thermo-regulator with the usual electrical connections operated a 200-ohm relay on a dry battery circuit of 4·8 volts. The thermostat was heated by an electro-gas unit of the Hahn type which was controlled by the relay (*Zeit. Physik. Chem.*, 1903, xliv., 525). The temperature of the bath was maintained uniform throughout the thermostat by a screw stirring device.

The hydrolytic reaction was carried out in a series of sealed tubes made from a very good grade of American glass. Into each tube properly cleaned were introduced 15 cc. of 0·1 N solution of the salt. These tubes were simultaneously submerged in the bath by means of a wire frame about fifteen minutes before the first reading was taken. In this way the solutions reached the temperature of the thermostat before the initial concentration was determined. After allowing this reaction to continue for definite time intervals, the tubes were removed and placed in ice-water to stop the reaction. The end-point of the reaction was determined by allowing the last tubes of the series to remain in the bath several days after the last time interval. Each reaction was carried out in duplicate.

The general equation for the action of water on the sodium salts of these halogen substituted acids may be expressed thus:—

$$R'CHX-R-COONa+H_2O= \\ =R'CHOH-R-COOH+NaX.$$

Previously most experimenters have followed the course

of the reaction by determining merely the amount of acid formed by titrating with standard alkali. The work of Johanssen (*Ber.*, 1915, xlviii., 1262) has shown that this method does not measure the true amount of hydrolysis, and so the following procedure has been adopted:—After opening each tube the contents were washed into a flask, and titrated with 0·1 N solution of sodium hydroxide using phenolphthalein as an indicator. This sodium hydroxide, prepared from metallic sodium, contained no carbonate. The free halide was then determined by titrating the neutral solution with 0·1 N solution of silver nitrate which had been made to exactly the same molar concentration as the alkali. A few drops of a concentrated solution of potassium chromate served as an indicator. This titration was very difficult in the presence of an iodide due to the colour of silver iodide which was formed.

The values of the velocity constants K_1 of a monomolecular reaction and K_2 of a bimolecular reaction were calculated by the usual titration formula given below. In all of this work the figures are based on the silver nitrate used for 15 cc. portions of the 0·1 N solutions of the salts.

$$K_1 = \frac{2 \cdot 3}{t_n} \{\log_{10}(T_\infty - T_0) - \log_{10}(T_\infty - T_n)\}.$$

$$K_2 = \frac{1}{t_n} \left[\frac{T_n - T_0}{(T_\infty - T_n)(T_\infty - T_0)} \right].$$

The hydrolysis of sodium chloroacetate has been previously studied by Senter (*Trans. Chem. Soc.*, 1907, xci., 466) and others. The salt was hydrolysed at 90°, and the values for K_1 determined. These were converted to constants at 70° by means of the factor 3·2 which Senter had previously determined as the temperature coefficient for each 10° (*Proc. Chem. Soc.*, 1908, xxiv., 89).

In Table I. are included the time intervals in minutes, the number of cc. of sodium hydroxide used in neutralising the solution, the number of cc. of silver nitrate necessary to precipitate the halide, and the values for K_1 at 90° and 70°.

TABLE I.—*Sodium Chloroacetate in* 0·1 N *Solution.*

t (mins.).	Cc. of NaOH.	Cc. of $AgNO_3$.	$10^5 K_1$ at 90°.	$10^5 K_1$ at 70°.
0	1·63	1·65	—	6·6
60	2·08	2·15	68·0	6·6
360	3·43	3·55	44·0	4·3
1200	6·08	6·25	42·0	4·1
1900	8·40	8·84	42·0	4·1
3420	9·85	10·35	39·0	3·8
7020	12·18	12·64	29·0	2·9
∞	13·93	14·25	—	—

Sodium bromoacetate has been hydrolysed by Kastle (*Am. Chem. Journ.*, 1893, xv., 484), and by Senter (*loc. cit.*), but at different temperatures. It will be noted that the values for K_1 at 70° (Table II.) are not as constant as those given by Senter at 52·4°. A satisfactory explanation of this irregularity will be given in a later paper dealing with certain homologues of acetic acid.

TABLE II.—*Sodium Bromoacetate in* 0·1 N *Solution.*

t (mins.).	Cc. of NaOH.	Cc. of $AgNO_3$.	$10^5 K_1$ at 70°.
0	1·90	1·93	—
60	2·86	2·90	(132·0)
240	4·10	4·42	90·6
600	6·70	7·30	89·8
1320	10·38	10·88	89·1
2010	12·03	12·70	88·6
2570	13·20	13·48	88·0
4020	14·10	14·40	85·3
—	14·80	14·85	—

Apparently the hydrolysis of sodium iodoacetate has not been studied before. It is more stable than the analogous bromine compound. These experiments have been repeated several times, and the results of one hydrolysis are given in Table III. No satisfactory explanation can be given at this time why it should be more stable than bromoacetic acid which is contrary to the usual rules of analogous bromine and iodine compounds.

TABLE III.—*Sodium Iodoacetate in* 0·1 N *Solution.*

t (mins.).	Cc. of NaOH.	Cc. of $AgNO_3$.	$10^5 K_1$ at 70°.
0	0·1	0·1	—
60	0·35	0·40	34·1
240	1·05	1·15	29·1
1440	4·85	5·15	29·0
2460	6·95	7·53	28·3
4080	9·73	10·10	27·6
6960	12·45	12·65	27·0
11280	13·95	14·00	22·9
—	14·90	14·90	—

Beckurts and Otto (*Ber.*, 1881, xiv., 576) and others in a qualitative study of the hydrolysis of sodium dichloroacetate found glyoxalic acid, sodium chloride, and dichloroacetic acid as products. The following equation represents this as a bimolecular reaction:—

$$2CHCl_2COONa + H_2O \rightarrow CHOCOOH + CHCl_2COOH + 2NaCl.$$

It would seem probable that there are two consecutive reactions, which may be expressed thus:—

(*a*) $CHCl_2COONa + H_2O \rightarrow CHOCOOH + NaCl + HCl$,
(*b*) $CHCl_2COONa + HCl \rightarrow CHCl_2COOH + NaCl$.

As reaction (*b*) should be instantaneous, we might expect that the hydrolysis of this salt should give constant values for a first order reaction.

Sodium dichloroacetate is very stable toward water, so it was hydrolysed at 90° and 100° (Table IV.). The temperature coefficient for each 10° was found to be 3·16 for a first order reaction and 3·40 for a second order reaction.

The results of this hydrolysis would tend to show that the reaction is apparently neither monomolecular nor bimolecular. At first it was thought that this might be due to the difference in the rate of substitution of the two chlorine atoms. Subsequent work has shown that this irregularity is found in the hydrolysis of salts of several halogen substituted acids which can only be monomolecular reactions. This will be discussed in detail in a later paper, from which it will appear that the hydrolysis of sodium dichloroacetate is a first order reaction.

TABLE IV.—*Sodium Dichloroacetate in* 0·1 N *Solution.*

t (mins.).	Cc. of NaOH.	Cc. of $AgNO_3$.	$10^5 K_1$ at 90°.	$10^5 K_1$ at 70°.	$10^6 K_2$ at 70°.
0	0·10	0·30	—	—	—
1440	3·83	4·13	9·1	0·91	0·026
2880	6·83	7·13	8·6	0·86	0·027
4320	9·25	9·48	8·1	0·81	0·028
7200	13·10	13·40	7·8	0·78	0·029
11520	16·95	17·23	6·8	0·68	0·030
17280	20·55	20·80	6·3	0·63	0·031
24480	23·70	24·10	5·9	0·59	0·037
—	31·05	31·40	—	—	—

In these tables it will be noted that a difference exists between the titration of the free acid and the halide liberated. Both Senter (*Trans Chem. Soc.*, 1912, ci., 2535) and Johanssen (*Ber.*, 1915, xlviii., 1262) have previously discussed this point. Senter believed that bromoacetoglycollic acid was formed as an intermediate product in the hydrolysis of sodium bromoacetate. This on subsequent hydrolysis produced glycollic acid. Although Senter has never been able to isolate his intermediate product he has prepared a similar compound, acetoglycollic acid, by adding sodium acetate to his solution of sodium bromoacetate.

$$CH_3COONa + BrCH_2COONa = CH_3COOCH_2COONa + NaBr.$$

The formation of a lactide or lactone was first suggested by Holmberg (*Ber.*, 1912, xiv., 1713), but it was not until

the work of Johanssen (*Ber.*, 1915, xlviii., 1262) that the β-lactone was isolated during the hydrolysis of β-chlorobutyric acid. Since the formation of a lactide has been found by Kastle (*Am. Chem. Journ.*, 1893, xv., 431), Walden (*Ber.*, 1893, xxvi., 262), and others in the hydrolysis of α-halogen substituted acids under certain conditions it may be considered an intermediate product in these reactions. Apparently this is the most satisfactory explanation of the difference in the alkali and silver nitrate titrations.

It has been shown by Lossen (*Ann.*, 1905, cccxlii., 122) and others that the hydrolysis of sodium trichloroacetate produces chloroform and sodium bicarbonate according to this equation :—

$$CCl_3COONa + H_2O \rightarrow CHCl_3 + NaHCO_3.$$

It is obvious that the course of the reaction must be followed by estimating the amount of sodium bicarbonate formed during the different time intervals. No good method could be found for the direct estimation of the bicarbonate in such dilute solutions so the following method has been adopted :—

The tubes containing the reaction mixture were taken from the thermostat, and placed in ice-water several minutes before opening them in order to prevent the decomposition of the bicarbonate into sodium carbonate and carbon dioxide. In this way all the pressure within the tubes was removed, and the mechanical loss of part of the solution on opening was prevented. The contents of the tubes were washed into a filter-flask containing 25 cc. of 0·1 N sulphuric acid. The flask was closed and attached to a vacuum pump which reduced the pressure to 2 mm. Several blank experiments with known concentrations of sodium bicarbonate proved that all of the carbon dioxide was removed by this treatment. Then the excess of sulphuric acid was titrated with sodium hydroxide, using phenolphthalein as an indicator. This method has proved fairly successful as shown by the results given in Table V.

TABLE V.—*Sodium Trichloroacetate in* 0·1 N *Solution*.

t (mins.).	Cc. of 0·1 N $NaHCO_3$ formed.	$10^4 K_1$ at 70°.
0	0·0	—
120	1·50	99·0
300	3·57	104·0
540	5·93	110·0
840	8·37	118·0
1200	9·73	110·0
1800	11·33	106·0
2760	12·05	86·0
—	13·28	—

This work shows that the sodium salts of the halogen substituted acetic acids have a relative stability in water solutions at 70° as follows:—Trichloroacetic acid, 1·0; bromoacetic acid, 1·2; iodoacetic acid, 3·6; chloroacetic acid, 26·0; dichloroacetic acid, 120.

This shows that chloroacetic acid is more stable than bromoacetic acid and iodoacetic acid, while iodoacetic acid is more stable than bromoacetic acid. It also shows that the introduction of the second halogen atom makes the acid much more stable toward water. We might expect that the introduction of the third chlorine atom would also have this same effect, but in this case the hydrolysis is not a true hydroxylation. From Table V. it is evident that trichloroacetic acid is the most unstable of the acids discussed in this paper.—*Journal of the American Chemical Society*, 1917, xxxix., No. 11.

Physical Society.—The Fourth Guthrie Lecture will be delivered by Prof. J. C. McLennan, of the University of Toronto, at the Imperial College of Science, on Friday, March 22, 1918.

THE UTILISATION OF WASTE TOMATO SEEDS AND SKINS.*

By FRANK RABAK, Chemical Biologist, Drug-plant and Poisonous-plant Investigations, Bureau of Plant Industry

Introduction.

THE manufacture of tomato products in the United States constitutes an industry of large and growing proportions and importance. Tomatoes serve as the basis for two general classes of products, in one of which the fresh whole tomatoes are used and in the other the pulp alone, as in the manufacture of catsups and soups. For this latter class large quantities of tomatoes are required, from which the seeds and skins at present are discarded as useless.

The increased interest in the production of foodstuffs throughout the country will doubtless result in an extension of all canning and packing operations, including tomato products. In the following pages attention is directed to the possible utilisation of the waste tomato material, not only from the standpoint of food conservation, but as a profitable adjunct to the tomato-canning industry.

Commercial Products from Tomato Refuse.

By proper treatment tomato refuse may be made to produce two important products, namely, fixed oil and meal, both of which possess considerable value. The seeds of the tomato contain a fatty oil of excellent quality, and the seed cake is valuable as a stock food.

Considerable work has already been done in foreign countries, especially in Italy, on the utilisation of tomato waste. Battaglia in 1901 investigated tomato-seed oil and reported on its properties. Later, Kochs in an investigation of certain residues, mentioned tomato-seed oil and discussed its properties, stating that 17·3 per cent of oil having an agreeable taste and smell could be obtained from the seeds.

In the manufacture of tomato products Italy perhaps leads all countries. The industry there has assumed such proportions that the problem of the proper disposal of the residues has become an important consideration. Perciabosco and Semeraro in 1910 investigated tomato residues with a view to extracting the fatty oils, determining also the industrial value of the oil and the fertiliser and feeding values of the residues after extraction. The oil extracted by carbon bisulphide was found to have properties similar to those of the oil previously reported by Battaglia. The fat-free residues were found to be useful for fertilising purposes.

Harcourt in 1907 called attention to the tomato refuse accumulating in increasing quantities at the canning factories in Canada. It was reported that a large portion of the refuse was flushed into near-by rivers, but in some cases it was allowed to accumulate near the factories, thus becoming a nuisance. Some of the refuse was spread over the land as a fertiliser. The manurial value was tested and found to compare favourably with barnyard manure in the three important elements, potash, phosphoric acid, and nitrogen.

Accomazzo in 1910 stated that in the province of Parma, Italy, 850,000 quintals (83,660 tons) of tomatoes were used annually. This quantity would yield from 11,000 to 12,000 tons of skins and seeds, containing about 80 per cent moisture. After removing the greater portion of the moisture the residue would amount to about 3000 to 4000 tons, of which about two-thirds are seeds. It is stated that these seeds when extracted by pressure yield 18 per cent of oil and by solvents 20 per cent. It would therefore be possible to recover from 500 to 600 tons of oil from the waste seeds. Tomato-seed oil is stated to have a heat value about equal to that of olive oil. When treated with driers it acquires good drying properties, and is also useful in soap making. The press cake is said to have excellent nutritive value.

* United States Department of Agriculture, *Bulletin* No. 632.

Fachini also recommends the extraction of oil from the seeds, but instead of drying the residue, as proposed by Accomazzo, he suggests a method of separating the seeds from the skins by agitating the material with water and allowing it to settle, whereupon the seeds fall to the bottom. The greater part of the water can then be removed from the wet seeds by centrifugal machines, after which the seeds are dried easily and the oil can be removed by extraction or pressure.

According to Consul Keena, Florence, Italy, the utilisation of tomato waste and the extraction of the oil from the seeds was first attempted by a firm in Parma in 1910. The success of the undertaking led to the establishment of two other factories the following year. About 5000 metric tons (1 metric ton = 2204 pounds) of wet tomato waste, corresponding to 1500 metric tons of dry waste, were worked out for the extraction of the oil and manufacture of the meal. These operations yielded 150 tons of oil, 800 tons of oil cake, and 500 tons of tomato skins.

Tomato-seed oil has been utilised in the manufacture of soap, and the conversion of the crude oil into an edible oil is also receiving attention. The press cake is used in the manufacture of stock feed, while the skins are suggested as a fertiliser.

The seeds are sold at Parma for 14 cents per 100 pounds, while at Naples the wet residue is sold at 4 to 8 cents per 100 pounds. This residue, which ferments readily, must be collected and dried daily. When dry it sells at 1.75 dols. to 2.20 dols. per 100 pounds.

More recently attention has been called by Shriver to the vast quantities of tomato seeds and skins accumulating as waste products from the rapidly growing canned-tomato industry in Italy. The problem of the proper disposition of this waste has been receiving attention since 1908, at which time a manufacturing plant was established in Milan, with branch-drying plants at Parma, Ceriale, Cervia, Piacenza, and Pilastro.

The oil is sold in the crude state for 7 dols. per 100 pounds, and the refined oil for 8.75 dols. per 100 pounds. The press cake is mixed with the skins and other ingredients and sold as stock feed.

The yield of oil from the seeds is stated by Shriver to be about 20 per cent by pressure and 22 per cent by solvents. In 1913 from 100 to 150 metric tons of oil and 1000 metric tons of stock feed were manufactured in Milan from the press cake and skins.

Bailey and Burnett, working with American tomato seeds, extracted the oil by pressure and found that it could be refined and bleached easily and was apparently a satisfactory food oil.

Accumulation and Disposal of Tomato Waste.

Percentage of Seeds and Skins.—For the preparation of tomato pulp the fresh tomatoes, after being carefully sorted to remove the culls, are thoroughly washed by a stream of water under pressure, then passed into receptacles where they are cooked with steam, and afterward are transferred to a cyclone machine, which removes the pulp. The seeds and skins pass out and are discarded. By the cold process the washed tomatoes pass directly to the cyclone machine.

The total quantity of tomato waste which accumulates annually in the United States depends not only upon the pack of any particular season but also upon the percentage of seeds contained in the fresh tomatoes. The seed content varies with the variety of tomato. Estimated from the figures given by Accomazzo Italian-grown tomatoes contain 14·7 per cent of wet waste, of which about 80 per cent is water. After removing the gr[illegible] water the waste amounts to 4·8 per ce[illegible] which probably still contains some m[illegible] is seeds. The dry waste as it occurs i[illegible] contain about 66 per cent by weight of [illegible] centages are considerably higher than [illegible] from American-grown tomatoes.

Two experiments in different localiti[illegible] American-grown tomatoes which had been used for pulping purposes, to determine the percentage of seeds and skins. The quantity of fresh tomatoes used in the two experiments were 2320 pounds and 5344 pounds respectively. The results were as follows:—Wet waste, 5·43 and 5·44 per cent; dry waste, 1·11 and 0·95 per cent. The dry waste in these experiments contained 46·3 and 42·8 per cent seeds and 53·7 and 57·2 per cent skins respectively.

According to Street fresh tomatoes contain 1·35 per cent dry waste, consisting of 49·3 per cent seeds and 50·7 per cent skins. Using these figures as a basis for calculation, American-grown tomatoes contain on the average about 1·13 per cent dry waste, of which 46·1 per cent is seeds and 53·9 per cent skins. Fresh tomatoes therefore contain the equivalent of 0·52 per cent dry seeds and 0·61 per cent dry skins.

In order to learn the approximate annual output of tomato refuse in the United States the writer personally visited twenty-one of the largest tomato-pulping firms. These manufacturing concerns operate largely in Indiana, Iowa, Michigan, and Ohio in the Middle West, and New Jersey, Pennsylvania, New York, Delaware, and Maryland in the East. Detailed figures regarding the output of refuse were not available in each State. The extent of the industry, however, may be realised when it is learned that in Indiana alone 120,000 tons of tomatoes are pulped annually. Applying the percentages previously mentioned, the amount of dry waste in this one State would be about 1356 tons, or 624 tons of seeds and 732 tons of skins.

Not all the firms engaged in pulping tomatoes could be reached; therefore accurate information in regard to the total quantity used annually could not be obtained. But from the figures given by the firms visited, supplemented by correspondence with other firms, it is estimated that 275,000 tons are pulped annually. Adding to this the tonnage of culls, from which also the seeds and skins could be separated, a conservative estimate would be about 300,000 tons.

This tonnage, of course, would vary from year to year. However, owing to the increasing demand for tomato products, the tonnage will tend to increase each year.

The quantity of wet waste resulting annually would be about 16,000 tons, which would yield approximately 3000 tons of dry waste. This dry waste would yield about 1500 tons of dry seeds and 1800 tons of dry skins.

Drying the Waste Material and Separating the Seeds.—An important problem in connection with the utilisation of tomato waste is the drying of the mass and separating the seeds from the skins. According to Shriver this problem is handled in Italy in the following manner:—

"The wet seeds and skins are passed through a press to remove as much of the moisture as possible. They are then passed through a desiccator, or drier, in which the material is kept in constant motion by means of horizontal conveyors, finally emerging from the machine in a dry condition. Heat is applied to the drier by means of steam pipes or by forced air."

It is stated that about 10 tons of residue can be dried in twenty-four hours. The final operation consists in passing the dried material through a machine supplied with a series of sieves and fans, which results in the complete separation of the seeds from the skins.

A number of types of desiccators, or driers, are manufactured in the United States which would be admirably suited for drying the wet waste. It has been suggested that a sugar-beet drier would handle the material efficiently. [illegible] should be experienced in constructing [illegible]ing of sieves and fans for the separation [illegible] the skins.

[illegible]*mato-seed Oil.*—Two methods of extrac[illegible] for obtaining fatty oil from seeds. The [illegible] perhaps the simplest and most expe[illegible] adapted to seeds containing a fairly [illegible] oil. The most careful manipulation of [illegible]er, leaves a residual portion of the oil

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TABLE I.—*Physical and Chemical Constants of Tomato-seed Oil from Domestic and Foreign Tomatoes (determined according to standard methods).*

Physical and chemical constants.	Domestic oil. Crude.	Domestic oil. Refined.	Foreign investigators. Accomazzo.	Battaglia.	Kochs.	Perciabosco and Semeraro.
Colour	Pale greenish yellow	Very pale yellow	—	—	Brownish red	—
Odour	Fatty, nutlike, slightly rancid	Fatty, bland, nutlike	—	—	Agreeable, tomato-like	—
Taste	Fatty, slightly bitter	Fatty, bland, nutlike; no bitter after-taste	—	—	do.	—
Specific gravity	0·9216 (*a*)	0·9184 (*a*)	0·920 (*b*)	0·922 (*b*)	0·920 (*b*)	0·9244 (*b*)
Index of refraction	1·4694 (*c*)	1·4715 (*c*)	—	1·4730	—	—
Congealing point	Turbid at 0° C.; yellow gelatinous mass at −7° C.	Turbid at 2° C.; solid, very pale yellow mass at −10° C.	—	—	Thick liquid at −9° C.	—
Acid value	8·8	2·5	—	26·3	9	1·823
Saponification value	190·4	188·6	183·6	190·4	183·6	189·4
Iodine value	108	114·2	117	106·9	117·8	87·7

(*a*) At 24° C. (*b*) At 15° C. (*c*) At 25° C.

TABLE II.—*Physical and Chemical Properties of Insoluble, Solid, and Liquid Acids of Tomato-seed Oils.*

Physical and chemical properties.	Insoluble acids.	Solid acids.	Liquid acids.
Colour	Pale golden yellow; partly solid	Snowy white, flaky	Pale golden yellow.
Odour	Fatty, nutlike	Fatty	Pleasant, nutlike
Taste	Sweetish, fatty	Fatty, tallow-like	Sweetish, nutlike, becoming slightly bitter
Specific gravity at 25° C.	0·9100	—	0·9013
Index of refraction at 25° C.	1·4655	—	1·4654
Congealing point	+21·5° C. to +20·5° C.	Melting-point, 53·5° C.	—
Neutralisation value	180	204	192·3
Iodine value	104·3	—	130

TABLE III.—*Physical and Chemical Properties of Tomato-seed Oil and several Important Oils of Commerce.*

Oils.	Specific gravity at 15° C.	Congealing point (° C).	Saponification value.	Iodine value.	Index of refraction at 20° C.
Tomato-seed	0·9184 (*a*)	Turbid at −2; pale yellow solid mass at −10	188·6	114·2	1·4715 (*b*)
Cotton-seed, Lewkowitsch	0·922 to 0·930	3 to 4	191 to 196·5	100·9 to 116·9	1·4722
Soy bean, Lewkowitsch	0·924 to 0·927	+15 to +8	190·6 to 192·9	121 to 124	—
Sesame, Lewkowitsch	0·9203 to 0·9260	−4 to −6	187·6 to 194·6	103 to 115	1·4728
Corn, Lewkowitsch	0·9213	−10 to −20	188 to 193·4	112 to 130·8	1·4768 (*c*)

(*a*) At 24° C. (*b*) At 25° C. (*c*) At 15·5° C.

TABLE IV.—*Composition of Tomato-seed Meal as compared with various Commercial Stock Feeds.*

Feeding stuff.	Constituents (per cent). Moisture.	Ash.	Protein.	Nitrogen-free extract.	Fibre.	Ether extract.
Tomato-seed meal	7·15	4·64	37·0	29·10	22·11	—
Cotton-seed meal	7·8	6·6	39·8	27·4	10·1	8·3
Sunflower-seed (prime)	10·0	4·2	34·8	21·8	10·9	18·3
Sesame-oil cake	9·8	10·7	37·5	21·7	6·3	14·0
Palm-nut cake	10·4	4·3	16·8	35·0	24·0	9·5
Rape-seed cake	10·0	7·9	31·2	30·0	11·3	9·6
Linseed meal (new process)	9·6	5·6	36·9	36·3	8·7	2·9

in the press cake. The expeller type of press is perhaps the best adapted for seeds having a comparatively low percentage of oil. Even with this type of machine a small percentage of oil remains in the press cake. This, however, is not a total loss, since the value of the cake is enhanced by the presence of some fat. A distinct advantage of the pressure method is in the better quality of the product obtained. Pressed oils usually contain less impurities, and consequently are more readily and effectively refined.

When the maximum percentage of oil is desired from certain materials the volatile-solvent method of extraction serves best. The principal solvents which may be employed are benzine, pretroleum ether, gasoline, and carbon tetrachloride. A disadvantage of this method is in the inflammability of many of the solvents, necessitating careful handling and operation. This trouble is largely overcome by the use of carbon tetrachloride, which is non-inflammable and possesses a higher boiling point than any of the other solvents, and hence is capable of effecting more complete recovery. Oils obtained by the solvent extraction method are usually less pure than expressed oils, containing much colouring matter and other impurities extracted by the particular solvent employed. No great difficulty is experienced, however, in refining the oils thus obtained. Pressed oils also require refining.

Apparatus of the continuous-extraction type is usually employed. This kind of apparatus minimises the quantity of solvent used and prevents loss of the solvent during the operation. Practically all the solvent may be recovered

from the oil and residue and thus be available for further use. A practical example of the use of a volatile solvent for the extraction of fatty oil is the use of benzine in the extraction of soy-bean oil. The disadvantages of the solvent method as compared with the advantages of the pressure method are largely offset by the lower cost of the apparatus, the smaller expense of operation, and the higher yield of oil obtainable.

Continuous extractors and hydraulic presses are obtainable from American manufacturers of chemical and pharmaceutical machinery.

Either of the two methods mentioned may be used effectively in the extraction of oil from tomato seeds. The solvent extraction method was used for obtaining the samples in the experiments described in this bulletin. The apparatus employed was the continuous-extraction type, the solvents used being ether and carbon tetrachloride. The yield of oil from the ground seeds with either solvent was practically the same, averaging 22 per cent. The crude oil was pale greenish yellow in colour, with a fatty, slightly rancid odour and fatty, slightly bitter taste.

In refining the crude oil the objectionable odour was removed by passing steam through the oil until little or no odour was perceptible. The deodorised oil was then heated on a steam bath for about one hour with fuller's earth (kaolin), and finally filtered while hot through filter paper. This procedure effected decolorisation of the oil to a marked degree. The refined oil possessed a very pale yellowish colour with bland fatty and agreeable nut-like taste and smell.

Physical and Chemical Properties of the Crude and the Refined Oils.—Some of the more common physical and chemical constants of the crude and the refined oils were determined, as shown in Table I. For purposes of comparison the properties of some of the tomato-seed oils of foreign origin are also included in the table.

From Table I. may be noted the general effect of the refining process upon the physical and chemical properties of the oil. The colour, odour, and taste of the refined oil show much improvement over the same properties of the crude oil. The specific gravity and index of refraction show changes due to the removal of impurities by the refining process. The congealing point of the refined oil has likewise changed. The acid value is materially lower than that of the crude oil, owing to the removal of the free fatty acids. The saponification and iodine values show similar differences due to the removal of impurities.

Among the oils of foreign origin the properties reported by Battaglia correspond more nearly to those of the crude oil of domestic origin, while the remainder compare favourably in most cases with the refined domestic oil.

Chemical Examination of the Oil.—In addition to the chemical constants a further examination of the refined oil was made to determine its approximate composition. The determinations were made according to standard methods. No soluble acids were found, but 96·2 per cent of insoluble acids were present. These insoluble acids were separated into the solid and liquid acids by means of the lead-ether method. The mixed acids were found to consist of solid acids 17·54 per cent and liquid acids 75·84 per cent.

The physical and chemical properties of the insoluble acids and the solid and liquid acids were determined with the results shown in Table II.

The solid acids, comprising 17·54 per cent of the oil, probably consist largely of palmitic and stearic acids with neutralisation values of 219·1 and 197·5 respectively. The neutralisation value 204 would indicate a mixture of these two acids. Although the melting-point of crude solid acids is considerably lower than either palmitic or stearic acids, which melt when pure at 62° C. and 69° C. respectively, it is very probable that this is due to the presence of impurities.

Calculating from the neutralisation value 204, the mean molecular weight of the solid acids was found to be 275. This indicates the presence of palmitic and stearic acids, since the molecular weight of these acids are 256 and 284 respectively.

In order to ascertain the approximate proportions of these two acids in the mixed solid acids a calculation was made according to the method suggested by Lewkowitsch using as a basis 275, the mean molecular weight of these solid acids. By this method the percentage of palmitic acid was found to be 67·8 and of stearic acid 32·2.

Since 17·54 per cent of the original oil consists of solid acids the oil therefore contains palmitic acid 11·88 per cent and stearic acid 5·64 per cent. Because the palmitic and stearic acids exist in the oil as palmitin and stearin it is necessary to reduce the above figures to terms of these glycerides. The glyceride palmitin contains 95·29 per cent of palmitic acid, and the glyceride stearin contains 95·73 per cent of stearic acid. By calculation, therefore, it is found that tomato-seed oil contains 12·47 per cent of palmitin and 5·89 per cent of stearin.

The liquid acids, constituting 75·84 per cent of the oil, possess properties which indicate the presence of oleic acid and possibly some linoleic acid.

The specific gravity of the liquid acids, 0·9013 at 25° C., would indicate a mixture of oleic and linoleic acids, since the specific gravity of pure oleic acid is 0·893 at 25° C. and linoleic acid 0·9206 at 14° C. The index of refraction corresponds closely with oleic acid, which possesses an index of refraction of 1·4603 at 25° C.

The neutralisation value of 192·3 is somewhat lower than that of pure oleic acid, 198·9, and pure linoleic acid, 200·4. The iodine value, 130, possibly also indicates a mixture of oleic and linoleic acids, with a preponderance of oleic acid. Some commercial oleic acids have iodine values as high as 100 to 110, while pure linoleic acid possesses an iodine value of 181·42.

Using the method of Lewkowitsch for calculating the approximate proportions of oleic and linoleic acids present from the iodine value as a basis, it was found that the liquid acids consist of 56·8 per cent of oleic acid and 43·2 per cent of linoleic acid. Reducing these percentages of oleic and linoleic acids to terms of the original oil, which consists of 75·84 per cent of liquid acids, it is found that the oil contains approximately 43·07 per cent of oleic acid and 32·76 per cent of linoleic acid. These acids are contained in the oil in the form of the glycerides olein and linolein, which contain 95·7 and 95·67 per cent respectively of oleic and linoleic acids. By calculation it is found, therefore, that the oil consists approximately of 45 per cent of olein and 34·2 per cent of linolein.

A summary of the results of the chemical examination of tomato-seed oil indicates the following approximate composition:—Olein, 45 per cent; linolein, 34·2 per cent; palmitin, 12·47 per cent; stearin, 5·89 per cent—the remaining portion consisting of free acids and unsaponifiable matter.

Available Quantity of the Oil.—Estimating the annual output of dry tomato waste from the various pulping plants in the United States at 3390 tons, there would result from this waste 1560 tons of dry seeds. The quantity of oil capable of being extracted from these seeds is readily ascertained. Since by extracting with volatile solvents 22 per cent of the oil can be obtained, the total available quantity would be about 343 tons annually. This quantity would, however, increase each year with the increased output of tomato products.

Uses and Value of the Oil.—Classifying fatty oils as drying, semi-drying, and non-drying, tomato-seed oil possibly falls into the semi-drying class, bordering, however, very nearly on the non-drying class. In order that the nature of tomato-seed oil may be better understood a comparison is given in Table III. of some of the more important properties of a number of oils of commerce belonging in the same class with tomato-seed oil.

The similarity of tomato-seed oil to the commercial oils given in Table III. indicates the classification of this oil. The oils mentioned in connection with tomato-seed oil are

applied commercially in a number of ways. As edible oils they are highly prized. On account of their drying properties some are employed extensively in the manufacture of paints and varnishes, while others find important application as soap stock.

Tomato-seed oil, with properties similar to cotton-seed, soy-bean, sesame, and corn oils, should be equally useful and applicable to the same purposes as these oils of commerce.

Experiments conducted with tomato-seed oil by Dr. A. D. Holmes, of the Office of Home Economics, U.S. Department of Agriculture, to determine its digestibility, showed that the oil possesses a coefficient of digestibility of 97, comparing favourably with olive, almond, cotton-seed, peanut, cocoanut, sesame, walnut, and brazil-nut oils. Well-refined tomato-seed oil is therefore to be recommended for culinary purposes. As a salad oil it should prove very satisfactory. The edible quality of the oil suggests also its possible hydrogenation and application as a margarine oil.

An experiment to determine its saponifying properties was conducted in order to obtain information regarding its possible use as soap stock. By cold saponification with caustic soda and subsequent salting and pressing a soap of good texture with excellent lathering qualities was produced. If combined with oils rich in palmitin or stearin, satisfactory toilet soap doubtless could be prepared. Owing to the present threatened shortage of oils for the manufacture of soaps and glycerine the utilisation of tomato-seed oil as a soap stock asserts itself.

Experiments to determine the drying properties of the oil showed that sixteen days were required to form a soft, sticky film. The nature of the film as well as the time of drying could in all probability be improved and hastened by the addition of siccatives or driers to the oil. It appears, therefore, that the oil possesses a certain value as a paint or varnish oil.

The value of the oil in commerce would necessarily depend upon the particular use to which it could be applied and to the demand in general for fatty oils. From the results of the investigation it appears that it should prove a valuable addition to the edible or condimental oils now in use. Likewise it should find an important place among the much-needed soap oils of commerce.

Tomato-seed Meal.

Utilisation for Stock Feeding.—The residue remaining after extracting the oil from the seeds constitutes the meal. The utilisation of this meal as stock feed is suggested. In order to ascertain the approximate composition of the meal a careful analysis was made. The results are shown in Table IV., together with analyses of some commercial stock feeds as given by Henry and Morrison.

In moisture and ash content the tomato seed meal compares favourably with the other feed stuffs. In protein content it ranks with sunflower-seed cake, cotton-seed meal, sesame-oil cake, rape-seed cake, and linseed meal, being considerably higher than palm-nut cake and somewhat lower than cotton-seed meal. Since the tomato-seed meal which was subjected to analysis was from ether-extracted seeds, the ether extract does not enter into consideration. The meal from seed expressed by hydraulic pressure would contain from 5 to 7 per cent ether extract, the b—represents the residual fat left in the cake. The centage content is relatively high as compared with the percentag being lower, however, than that of palm-nut ever, is no content of nitrogen-free extract, consisting hanced by t—ohydrates, is higher than in such meals as of the pressu—flower, and sesame, and lower than in duct obtained—ed, and linseed cake.

purities, and co—of the analysis and the comparison with refined. it would appear that tomato-seed meal

When the maxi— considerable value for stock feeding. certain materials th— may be stated that in Italy, where serves best. The —to residues is in practical operation, ployed are benzine. tetrachloride. A

experiments with the meal or cake have demonstrated its value as a feed for stock. Aguet has reported a factory in operation at San Giovanni a Teduccio, near Naples, for the industrial manufacture of tomato-seed cake. Feeding trials conducted at the Royal Higher School of Agriculture at Portici with milch cows showed tomato-seed cake to be equal in food value to linseed cake. Later, Scarpitti conducted extensive investigations with the seed cake as a feed for milch cows, stating that it is richer than flax-seed cake in protein and fat and is superior to it in its influence upon the weight and lacteal secretion of the cows.

Shriver describes the manufacture of stock feed from the dried tomato waste after the extraction of the oil. A number of grades of stock feed under the name "Nutritivo" are manufactured by a firm at Milan, Italy, from the dried skins mixed with molasses and the meal from the extracted seeds. This feed for cattle is sold at prices ranging, according to quality, from 1.32 dols. to 1·49 dols. per 100 pounds. The seed cake after the oil is expressed is sold at 1.32 dols. per 100 pounds.

Available Quantity of the Meal.—After extracting the oil from the estimated quantity of tomato-seeds which accumulate annually, there would remain as a by-product about 1200 tons of the meal. In additional to this large quantity of meal there would also be available about 1800 tons of tomato skins. In view of the use to which the dried skins are applied in Italy by incorporating them with the meal this would increase the total available quantity to about 3000 tons.

Summary.

The foregoing investigation shows that the vast quantities of tomato refuse accumulating each year at tomato-pulping factories can be reduced to two products, namely, fixed oil and meal, each of which may be made commercially useful.

The oil from the seeds should find ready disposal as an edible oil or as a soap oil, as shown by the experiments made to determine its applicability to these purposes. By proper treatment it can be made useful as a drying oil for paint and varnish purposes.

The meal has been shown by analysis and comparison with other meals to possess valuable qualities as stock feed, and the utility of the meal for this purpose should therefore be assured.

The accumulation of tomato residues occurs principally in two sections of the United States, namely, the North-Central States lying east of the Mississippi and north of the Ohio Rivers and the North Atlantic States. The reduction of this waste material to oil and meal could be handled most logically by establishing reducing plants at some central point in each of these sections, where the crude material could be collected with the least expense for transportation and handling. A co-operative plan of manufacture would perhaps be the most feasible and effective method for establishing the industry upon a practical basis.

In view, therefore, of the threatened shortage of fatty oils and in the interest of food conservation, tomato refuse may be considered as an available source for the manufacture of oil and oil cake. As the demand for tomato products increases the quantity of this waste material will also increase, and it is suggested as an economic measure of both agricultural and industrial importance that the utilisation of this material be considered.

Trade Marks.—The Trade Marks Committee of the Federation of British Industries has decided to oppose Part 2 of the proposed new Government Bill "To Amend the Trades Marks Act, 1905," on the ground that it will inflict serious injury on the owners of perfectly legitimate Trade Marks. Part 2 deals with "Provisions for the Prevention of Abuses of Trade Marks." It has also been decided by the same Committee that the proposed British Empire Trade Mark should be opposed.

NEW LECTURESHIP IN INDUSTRIAL MANAGEMENT.

MANAGEMENT is one of the professions for which universities prepare their students of applied science and technology. The Manchester School of Technology has recognised that many of its undergraduates, after completing their course of training by adding practical works experience to academic studies, will before long occupy positions as managers. However well a man may be up in technical knowledge, and whatever acumen for research he may possess, he is not necessarily qualified for a managerial position. Short courses of lectures on management, on costing, and on economics have therefore formed part of the university courses taken by candidates for the degree of B.Sc. Tech., whether in engineering, applied chemistry, or textile technology. Short courses of public lectures on various aspects of industrial management have also been provided in the School of Technology.

But this is not enough. The science and practice of works management ought to be studied by the works manager of the future, not merely as a subsidiary subject, but as an essential element of his university training. Moreover, the works manager of to-day should be given the amplest opportunities of acquainting himself with this new science as it continues to develop and to be practised in the industries of this country. In short, the works manager—whether of the present or future—must be given every opportunity of understanding the human as well as the material element of his industry.

With this end in view a group of large firms engaged in the principal industries of the Manchester district have offered to the Governing Body of the School of Technology the sum of £3000, spread over a period of five years, towards the cost of establishing a new department of Industrial Management. The Manchester Education Committee to-day recommended that this gift be accepted and expressed their high appreciation of the donors' public spirit.

It is proposed that a lecturer shall be appointed for this period of five years at a salary of £600, to conduct research in the subject of industrial management, to organise a new department, to lecture to members of the University and to the public, and to assist industrial concerns in the solution of management problems. To make doubly sure that the department shall keep in close touch with practice a number of managers, directors, scientific experts, and others who have had special experience or are responsible for important innovations, will be invited to deliver public lectures, being offered substantial fees which will not only pay them for placing their knowledge at the disposal of their fellow-managers, but serve to encourage enterprise and experiment in matters connected with management. These lectures should be of assistance not only to future managers, but to those already in that position; they will strengthen the idea that management is a science, and that every manager is, or should be, something of a scientific researcher.

No one expects by such means to find a panacea for labour troubles. Modern science does not believe in panaceas. But the suggestion marks a breach with the past secretive tendency of private business—concealing all discoveries—and adopts instead the scientist's practice of making known. It also recognises that the new science of industrial administration must be concerned with working out practical details as well as with framing a general policy.

If British industry is to repair the loss of war, if the conditions and standard of life are to improve, production must increase and must become more scientific, less wasteful than it has been. Increased production depends on two things—a scientific system, with attention to details, and its being worked in the right spirit. Greater interest, greater pay, greater leisure, and lower prices are good things for all, whatever be the ultimate destiny of capital, and scientific industrial management must try to compass these in whatever world we find ourselves—the world of Rockefeller, of Sorel, or of Mr. Webb.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, February 7, 1918.

Sir J. J. THOMSON, O.M., President, in the Chair.

PAPERS were read as follows:—

"*Photo-electric Action of X-Rays.*" By Prof. O. W. RICHARDSON, F.R.S.

In this paper the excitation of electron emission by X-rays is discussed in relation to our knowledge of the photo-electric action of other types of radiation. The main conclusions are the following:—

1. The ratio E_K'/E_A of the energy E_K emitted in the form of K secondary X-radiation to the energy E_A of the primary radiation (wave-length λ) absorbed is found in the case of bromine to be expressed to within the degree of accuracy of the available observations by the formula—

$$E_K/E_A = \frac{\lambda}{(1+p)\lambda_K}$$

where—

$$p = e^{-0{\cdot}46 \frac{\lambda_{K\gamma}-\lambda}{\lambda}}$$

λ_K is the average wave-length of the K radiation and $\lambda_{K\gamma}$ is the wave-length of the shortest K radiation.

2. The formula implies, or at any rate can be so interpreted as to imply, the emission of one electron for every quantum ($h\nu$) of primary radiation absorbed. It likewise involves for the emission of each quantum of K radiation the absorption of one quantum of primary radiation when $\nu = \infty$, of two quanta of primary radiation when $\nu = \nu_{K\gamma}$, the limiting (threshold) frequency for excitation, and of amounts of primary energy varying between one and two quanta for exciting radiations of intermediate frequency.

3. Inasmuch as the formulæ have been deduced, and have been given a plausible explanation, on the hypothesis that the primary radiation is absorbed in whole quanta, it does not appear that the facts under consideration can be held to support the contrary hypothesis.

"*The Parent of Actinium.*" By F. SODDY, F.R.S., and J. A. CRANSTON.

1. In a full historical introduction the data obtained in 1909 relative to the rays and products of uranium-X are discussed, in so far as they throw light on the various possible modes of origin of actinium.

2. The minute growth of actinium previously put on record in 1913 as having been observed in the old uranium-X preparations has been confirmed by their later history, and is now established beyond doubt.

3. Uranium-X_2 can be separated from uranium-X_1 by sublimation in a current of air charged with vapours of carbon tetrachloride at a temperature below visible red-heat.

4. 470 grms. of a very pure Indian pitchblende were similarly treated in the expectation of removing eka-tantalum isotopic with uranium-X_2, and giving actinium in an α-ray change of long period.

5. The preparations so obtained were initially free from actinium, but one of them has produced it continuously with the lapse of time.

6. A direct comparison of the amount of actinium in this preparation after the lapse of 2·5 years with that in the original pitchblende showed that it was equal to that in about 0·25 grm.

7. On the assumptions that eka-tantalum and actinium are both long-lived, that no intermediate members inter-

vene between them, and that the preparation contained the whole of the parent of actinium in the original mineral, the period of average life of actinium is calculated to be 5000 years. Nothing can yet be said definitely as to the period of the parent.

8. A second preparation separated from Joachimsthal pitchblende, the treatment of which commenced in 1903, and ended in 1914 with the carbon tetrachloride sublimation, has given a similar growth of actinium.

9. The work was undertaken to test and confirm the view that the parent of actinium occupies the eka-tantalum place in the Periodic Table, and gives actinium in an α ray change of long period, itself being formed as the product of uranium-Y, discovered by Antonoff, who suggested that it was the first member of the actinium series. But this mode of origin of actinium, though at present the most probable, is not yet conclusively established to the exclusion of *all* the other possible modes of origin, discussed in the historical introduction.

"*Some Problems in the Theory of Radiation.*" By Prof. Arthur Schuster, Sec.R.S.

This paper deals with the oscillatory energy taken up by a simple resonator under the action of white light, and the translatory energy imparted to a molecule by radiation.

The first problem has been treated by Planck. It is solved here in a very simple manner, and the method used, when applied to the second problem, leads to the important result that a molecule at rest, within an enclosure of uniform temperature, will, while taking up an oscillatory energy, be set in motion with an acceleration that will increase its speed until the average energy reaches a definite value. If the Rayleigh-Jeans laws of radiation be assumed to hold, the ultimate average energy due to radiation alone is two-thirds of that derived from the kinetic theory of gases.

"*Absorption of the Radiation emitted by a Palladium Anticathode in Rhodium, Palladium, and Silver.*" By E. A. Owen.

1. A short account is given of some preliminary experiments carried out with the rays from an ordinary X-ray bulb.

2. A spectrum of the rays from a palladium anticathode is obtained over a limited range of wave-lengths by reflection in the (111) face of a carborundum crystal. The spectrum shows that the bulb emits a continuous band of wave-lengths upon which are superposed the characteristic rays of the metal of the anticathode, and under the conditions of working in this particular case the relative intensities of the different wave-lengths in the spectrum remained approximately constant.

3. The "end radiation" of the bulb was found to be very homogeneous.

4. There is a minimum of intensity in the spectrum corresponding to the wave-length $0{\cdot}493 \times 10^{-8}$ cm. On the assumption that the minimum is due to the selective absorption of this wave in the crystal, the value $0{\cdot}493 \times 10^{-8}$ cm. is assigned to the β-line of the J-series of silicon. From the experimental results of Barkla and White on the J-series of the elements Al, C, and O, the approximate values deduced for the β-line of the J-series of oxygen and carbon are $0{\cdot}519 \times 10^{-8}$ cm. and $0{\cdot}559 \times 10^{-8}$ cm. respectively.

5. Assuming Bragg's mean value of the α-line of palladium to be $0{\cdot}586 \times 10^{-8}$ cm., the following values are obtained for the wave-lengths of the β- and γ-lines:—

$$\beta = 0{\cdot}520 \times 10^{-8} \text{ cm.}; \quad \gamma = 0{\cdot}509 \times 10^{-8} \text{ cm.}$$

6. The absorption coefficients of the rays from the bulb have been measured in rhodium, palladium, and silver. The results show that the relation between wave-length and absorption coefficient is expressed by the relation $\tau/\varepsilon = K\lambda^3$ where τ/ε is the fluorescent coefficient and K is a constant for a given substance over the range of wave-lengths between the absorption bands of that substance.

7. The critical wave-length necessary to excite the characteristic rays of a substance lies in the neighbourhood of the β-ray of that substance. The α-ray is not excited until the β-ray is excited.

8. It is pointed out that the purity of the characteristic lines emitted by a bulb and isolated by reflection at a crystal face will depend, to a great extent, upon the state of working of the bulb.

RÖNTGEN SOCIETY.

The important part played by radiography at the present time in the diagnosis and treatment of wounds inflicted in warfare, has led to a greatly increased interest being taken in the work of the Röntgen Society of London. It is felt by the Council of the Society that its scope may be still further enlarged if additional support is forthcoming by the aid of an increased membership.

The Röntgen Society was founded in 1897, the first President being the late Prof. Silvanus P. Thompson, F.R.S. It was promoted to study X rays and allied phenomena. The meetings are ordinarily held on the first Tuesday of each month from November to June, and on these occasions papers are read dealing with the technique of radiography, the physical aspects of the subject, improvements in apparatus and equipment, while discussions are also organised on questions of general radiological interest.

Other privileges and features of the Society may be noted. Periodical exhibitions of radiographs or apparatus showing features of special interest are arranged, and on those evenings members and their friends are cordially invited to send suitable exhibits. The Journal of the Society is published quarterly, it contains the proceedings of the Society, together with notes, abstracts of papers published at home and abroad, and other matters of radiological interest; it is sent to all members. The "Silvanus Thompson Memorial Lecture" is given annually in memory of the first President of the Society. Distinguished workers in radiology or allied subjects from this country or abroad are invited by the Council to deliver the discourse. The Society possesses a good library of works dealing with radiology, which may be consulted by the members. Special Committees selected from members of the Society are arranged to encourage research and to advise the X ray industry generally. A Committee is at present engaged on the "Dosage" question, while an Advisory Committee has been appointed to give practical effect to the discussion on "The Future of the British X-Ray Industry." The Society owns an extensive collection of X-ray tubes of historical interest. These are at present housed in the Loan Collection of the Victoria and Albert Museum at South Kensington.

Candidates for membership must have shown some active interest in the subject of radiology. If approved by the Council, they are nominated for election by ballot at the next meeting of the Society. The Annual Subscription is One Guinea, payable in advance. A composition fee of Fifteen Guineas entitles a member to life membership. A booklet containing fuller information regarding the Society, together with a list of members and nomination forms, may be obtained on application to the Honorary Secretaries—Robert Knox, M.D., 38, Harley Street, London, W. 1; Sidney Russ, D.Sc., Middlesex Hospital, London, W. 1.

Cotton Industry in Korea.—A company has been formed for the purpose of erecting a mill and carrying on a cotton-spinning and weaving industry in Korea. The mill will spin fine yarns and manufacture shirtings from Korean upland cotton. According to the *Eastern Engineer* it is hoped that the enterprise will prove much more profitable than similar undertakings in Japan because of the local supply of raw material and of the cheap labour available.

NOTICES OF BOOKS.

Treatise on Applied Analytical Chemistry. By Prof. VITTORIO VILLAVECCHIA. Translated by THOMAS H. POPE, B.Sc., A.C.G.I., F.I.C. Vol. I. London: J. and A Churchill. 1918. Pp. xvi+475. Price 21s. net.

THE translation will be acceptable to analytical chemists in this country, as, although there is no lack of authoritative text-books on technical analysis, it is useful to know the standard methods adopted in other countries, and the author's very wide experience gives great value to the opinions he expresses. All the methods described are those which are most frequently used in practice, and have either been officially prescribed, or else have been frequently tested, being in fact in almost daily use in the laboratories under Prof. Villavecchia's direction. Generally only one, or at the most two methods are given for each separate test, and tables are given showing the average results of the analysis of commercial samples. Volume I. deals with water, the principal products of the inorganic and organic chemical industries, oils and fatty substances, metals, fuels, tar, and cements. Some slight changes have been made when the practice in this country differs from that of Italian chemists, but otherwise the translation closely follows the original text.

Reagents and Reactions. By EDGARDO TOGNOLI, M.D. Translated from the Italian by C. AINSWORTH MITCHELL, B.A., F.I.C. London: J. and A. Churchill. 1918. Pp. viii+228. Price 6s. net.

IN this book well-known tests and the most important chemical reactions are arranged alphabetically under the names of their discoverers, and full instructions are given for carrying out the tests. They are also indexed under the names of the substances to be examined or detected, so that the user of the book should have no difficulty whatever in finding any test he requires, even if he has no very clear recollection of the name of the chemist who first applied it. The usual tests for the purity of reagents are also included and tables of specific gravity of solutions, &c., and the book will be found a very useful addition to the library attached to an analytical laboratory.

Le Centenaire de Charles Gerhardt. ("The Centenary of Charles Gerhardt").

THIS supplement to the *Bulletin de la Société Chimique de France* contains the admirable Address of the President of the Society, M. Camille Poulenc, on the occasion of the celebration of the centenary of Charles Gerhardt. The President made a careful comparison of German and French mentality as shown in the work of the chemists of the two countries in Gerhardt's time, and pointed out that the latter's aim was always and only the discovery of the truth and never self-aggrandisement. The remarkably fruitful work done by Gerhardt during his short life was adequately described by M. Marc Tiffeneau, who gave a sound estimate of its true value.

Methods in Metallurgical Analysis. By CHARLES H. WHITE. London: Constable and Co., Ltd. 1917. Pp. ix+356. Price 10s. 6d. net.

THE methods of metallurgical analysis which are most widely used in American laboratories are well described in this book. The author believes that it is quite possible for a student to begin his work in quantitative analysis by doing metallurgical determinations, provided that he has had a thorough training in qualitative analysis, and if he has the right kind of book to work from there is no doubt but that this is quite a correct view. Moreover, it is probable that apart from the saving of time there will be a positive advantage in learning the technical applications of the various processes while becoming familiar with the actual operations. This book appears very well suited for this special purpose; the first experimental work is described in full detail, and the various methods employed in the analysis of iron ores are so carefully explained that beginners should have no difficulty in getting satisfactory results from actual commercial products. Even the more difficult processes ought to be found well within the powers of the average student, and if he works straight through the book he will gradually acquire a sound knowledge of methods and technique. The analysis of iron and steel, bullion, many common alloys, and fuels of all classes, and some methods for the estimation of the less important metals are included.

CORRESPONDENCE.

GRAVITATION AND MAGNETIC ATTRACTION.

To the Editor of the Chemical News.

SIR,—Mr. T. J. J. See, of Montgomery City, Missouri, has just published a theory by which he undertakes to disclose the physical cause of gravitation and magnetic attraction. For such a result he, not unnaturally, makes large claims to recognition. Incidentally he takes occasion to attack, with much acrimony, a learned society which failed to seize the opportunity afforded by an early communication to insert his first paper among its proceedings, and on the subject of his grievance he is not less vocal than on the subject of his discoveries. May I be allowed to point out, therefore, that Mr. See himself supplies the answer to his own complaint, for his papers, now published, do not contain what alone would warrant any learned society in giving its imprimatur to the work; that is to say, a proof of the hypothesis which Mr. See proposes for the acceptance of his readers.

Stated shortly, Mr. See suggests that the attraction of magnets for one another and the phenomena of universal gravitation are both to be explained by aetherial undulations of the nature of light and radiant heat, and a theory is elaborated upon this basis which is said to find its unmistakable and sufficient proof in certain fluctuations of the moon's mean motion which have been observed in connection with lunar eclipses. Concerning the importance to be attached to that proof it is sufficient here to say that the coincidence between calculated and observed fluctuations is not exact, and that while some readers will probably take the author's view that they are strikingly close, others will be impressed with their inconclusiveness. Their value in the argument which Mr. See has started is, therefore, not a very suitable topic for discussion in this letter.

But what I ask leave to point out is that in the development of his theoretical argument Mr. See is strangely and even inexcusably careless. Thus he bases his entire case upon the well-known formula for the curve to a plane wave front.

$$y = A \sin \left\{ \frac{2\pi}{\lambda} (Vt - x) + a_i \right\}$$

Now this formula expresses the connection between different phases of one wave front, the term a_i serving to identify a particular wave front or, as the case may be, the successive waves of an homogeneous train of waves originated by one rhythmically pulsating source. But Mr. See, for the purpose of his argument, ignores this limitation and employs the formula to connect supposed undulations originating in independent sources and not characterised by a common value for the phase term a_i. An oversight such as this deprives his whole argument of force.

Another point of difficulty in Mr. See's proposed explanation is that he assumes λ in the above formula, as applied to magnetic and gravity waves, to have only one value. This seems to be a very arbitrary assumption. It does not hold good in the typical case of light, with which we are most familiar, and it seems overbold to assume that it holds in the case of magnetic waves, for example. The question may be put in this way. Is it obvious, is it even probable, that an atom of copper sets up magnetic undulations of the same wave length as the

magnetic undulations of iron, if both the iron and the copper are limited each to undulations of one wave length? Should we not expect to find that, as in the case of light, each atom has its own wave length period and that all the phenomena of resonance and interference depend upon the interplay of periodic forces which are conditioned by these diversities among different atoms? The explanation itself thus seems to present extraordinary difficulty.

Even if these preliminary difficulties were removed there would remain another, not less serious, perhaps. Mr. See, when discussing magnetic attraction, assumes opposed undulations to interpenetrate one another and by acting simultaneously upon the same quantum of ether to reduce the stress in it. Now why this coincidence of opposed forces in place and time should reduce the local stress is by no means obvious. The difficulty may be illustrated by a familiar example. Take the case of a heavy body in motion which is urged forward by its momentum—say for example, a billiard ball gliding over a billiard table. If such a ball meets another there is an exchange of *momenta between them which is dynamically equivalent* to interpenetration. Thus, if they meet in the same straight line we observe that after collision each runs back upon its path with the velocity of the other ball, so that the whole result is the same dynamically as if the balls had passed through one another and moved on afterward unaffected by the collision. Now, there is a sense in which the local stress was momentarily reduced by the collision, if we confine our attention to momentum and call that, and that only, "stress." For there was an instant in which both balls were at rest before they moved off in opposite directions. But it would be a very superficial view to describe this instantaneous disappearance of momentum as a *reduction in stress. For the fact is* that the stress has taken a new form and is now elastic tension set up in the deformed balls. They will forthwith resume form, and, with their forms, they will acquire fresh momenta. The stress, therefore, persists, although the momentum disappears. If it did not persist, as, for example, if the balls broke up under the force of impact, their energy would be dissipated and their momenta would not be interchanged.

Now it would seem natural to suppose that, in like manner, if two opposed wave motions co-operating on the *same quantum* of ether were to produce reduction of magnetic stress, it could only be, either by causing dissipation of the accumulated energy or, *alternatively, the production* of equal stress of some other type. In the one case the interaction would tend to destroy, not to produce, magnetic phenomena, and in the other case it is not at all apparent why the change from magnetic to, say, thermal, or some other form of stress, should conduce to contraction of the stressed medium.

When it comes to the law of gravitation the difficulty of Mr. See's hypothesis increases. Very obvious considerations would seem to be conclusive against it. For example, it is elementary that gravitation is strictly proportional *to the mass of the gravitating body*, whereas radiation, such as Mr. See proposes to explain it, is a function, not of mass only, but of *surface no less than* of mass. Take the case of an unsymmetrical mass, say of hemispherical form. Such a body, if it exerted its attraction of gravitation by means of aetherial undulations, would radiate gravitation as the moon, for example, radiates light. Along one axis its energy would be proportional, say, to the light of the full moon—along an *axis at right angles to* that one it would be proportional to the light of the moon in her first or third quarter. Is there *any evidence at all for any such spatial distribution* of the force of gravitation?

Obvious difficulties such as this are wholly ignored in Mr. See's papers. Is it not fitting, therefore, that, if published at all, they should be published upon his sole responsibility?—I am, &c.,

J. W. Gordon.

112, Broadhurst Gardens, N.W. 6, Feb. 19, 1918.

NOTES AND QUERIES.

*** Our Notes and Queries column was opened for the purpose of giving *and obtaining information likely to be of use to our readers generally.* We cannot undertake to let this column be the means of transmitting merely private information, or such trade notices as should legitimately come in the advertisement columns.

Cobaltum Steel.—Can any reader suggest a method for the analysis of "cobaltum" steel? The difficulty I find is to obtain a suitable solvent. Though some text-books give concentrated hydrochloric acid for "stellite"—which contains *practically* the same elements, only in different proportions—I am not able to obtain a complete solution, and think tungsten must be present, though none has been given in the maker's analysis. I shall be glad if any reader can show some light on this subject.—W. Auckland.

MEETINGS FOR THE WEEK.

Monday, 4th.—*Royal Society of Arts*, 4.30. (Cantor Lecture) "The Effect of the War on the Economic Condition of the United Kingdom—the Real Cost of the War—and the Problem of Economic Reconstruction," by Edgar Crammond.

Tuesday, 5th.—Royal Institution, 3. "A National Laboratory of Industrial Research," by Sir Richard T. Glazebrook.

— Royal Society of Arts, 4.30. "Portugal as a Colonial Power," by George Young, M.V.O.

Wednesday, 6th.—Royal Society of Arts, 4.30. "The Foundation of Industrial Peace," by A. H. Paterson.

Thursday, 7th.—*Royal Institution*, 3.

Friday, 8th.—Royal Institution, 5.30.

Saturday, 9th.—Royal Institution, 3. "Problems in Atomic Structure," by Sir J. J. Thomson.

TO comply with Regulation 8 (*b*) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Chemists (Men or Women) wanted, with University Degree or its equivalent, for an Explosives Factory in the South of England.—Box 626, Leathwait and Simmons, 5, Birchin Lane, E.C. 3.

Chemists wanted by important Company with large works in the East. Assistants with sound knowledge, Practical and Theoretical, of Organic and Analytical Chemistry. Three years' engagement; passage out and home. Single men only should apply, stating full particulars, age, qualifications, experience, &c., to Z.O. 159, care of Deacon's, 7, Leadenhall Street, E.C. 3.

Elderly Chemist, has assisted Public Analyst, desires Post with short hours in London.—Address, F. C., 56, Handsworth Road, Tottenham, N. 15.

Metallurgical Chemist wanted for Brass Foundry in Birmingham. Only a capable man should apply. Salary £5 per week.—Address, "M.C. 5," Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, Chemists for Process Control in large Chemical Factory engaged on War work. Good salary and prospects of advancement to well-trained and experienced men *who can handle a shift with tact and energy and show efficient results* in manufacturing operations.—Address, P. C., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, Women Chemists trained in the use of the Balance and simple Analytical operations for the Laboratory of Chemical Factory engaged on Aircraft Work.—Address, W. W., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

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THE CHEMICAL NEWS

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KNOWLEDGE IN POWER.*

In 1892 Sir William Crookes exhibited, at one of the *soirées* of the Royal Society, an experiment on "The Flame of Burning Nitrogen." He showed "that nitrogen is a combustible gas, and the reason why when once ignited the flame does not spread through the atmosphere and deluge the world in a sea of nitric acid is that its igniting point is higher than the temperature of its flame—and not, therefore, hot enough to set fire to the adjacent mixture. But by passing a strong electric current between terminals the air takes fire, and continues to burn with a powerful flame, producing nitrous and nitric acids."

In 1898 Sir William gave to the British Association the Presidential Address from which the foregoing is quoted, with the succeeding sentence, illustrating the human intellect at its greatest:—

> *This inconsiderable experiment may not unlikely lead to the development of a mighty industry destined to solve the great food problem.*

As a medical student, who had that summer given up the game of games for an advanced course in physiological chemistry, I read that great Address in the *Scotsman* the next morning, marvelling at the breadth of its vision, the length of its prevision, the area of its inchoate provision.

In the year 1906 I asked Sir William to contribute to a scientific series a book on this theme, the fixation of nitrogen to feed the Western world. He sent me a copy of his Address, in the form of a paper-covered volume, and courteously pleaded "advancing years" as preventing more. He was then seventy-four, and the best of the joke is that, twelve years later almost to a day, I have what I asked for in my hand, thanks to *The New Statesman* and Lord Rhondda. For this is a new edition, in effect a new book, on the theme of *twenty years ago*, and its author will be eighty-six in a few months. ("The Wheat Problem," by Sir William Crookes, O.M., F.R.S., Third Edition; with a chapter on "Future Wheat Supplies," by Sir R. Henry Rew, and an Introduction by Lord Rhondda, &c., 3s. 6d).

In July, 1915, our position regarding food and explosives and tonnage was already ominous, whilst our blockade was clearly failing to defeat Germany, thanks to her use of Sir William's work and the lessons he had drawn from it near the end of the nineteenth century. As for ourselves, we had done nothing. (The Mendelian or other genetic system which will explain why a people so incurably stupid in the mass as ourselves beats the world in the production of men of every kind of genius, except music and painting, has not yet been announced). The danger was extreme, and the first thing was to draw general attention, in departmental and all other quarters, to the teaching of our illustrious chemist, and its meaning for our lives and our cause.

Within three days of the publication of my article there reached me from the editorial office an offer addressed to "Lens," to pay for the proper re-writing, by a thoroughly competent expert, of Sir William's book, and for its re-publication. The letter came from Lord Rhondda, who was *then, unfortunately for us, merely minding* his own business in Cardiff, and not the nation's in London. But he had time, even then, to raise a hand to feed our mouths and our guns. And so I had my way, and the reader who knows what is now being done will forgive me if I cannot refrain from patting my pseudonymous pen in public.

* From *The New Statesman*, Feb. 13, 1918.

In the *month following publication of my article*, inventors drew the attention of the Munitions Inventions Department to the need for fixing nitrogen, and in October, with the help of Mr. Montagu, then the Minister of Munitions, and at a meeting which Sir William Crookes honoured *with his presence, there was formed a* "Nitrogen Products Committee," a recent report of which, entitled "The Nitrogen Problem," is before me. This Committee has done and is doing magnificent work—without which we should be nowhere now; but the time for its discussion will be when it issues its Final Report, at some future date.

Meanwhile, leaving the explosives part of the nitrogen problem for future consideration by a chemist, let us consider its bearing on food, for the urgent present and the scarcely less urgent future. In his Introduction, Lord Rhondda states the essentials in their order and proportion. If we are to grow food, we should grow the best food—which is bread, and above all wheaten bread. The Corn Production Act increases the wheat area, but science must increase the yield per acre. Consider now the dreadful, damning Yellow Book of the Board of Agriculture (Cd. 8305). The facts have often been cited, but I quote them here again, as there is need, from Sir William (p. 45):—

Table XI.—*Average Farm Produce of 100 Acres of Cultivated Land.*

Great Britain.	Germany.
15 tons corn.	33 tons corn.
11 tons potatoes.	55 tons potatoes.
4 tons meat.	4½ tons meat.
170 tons milk.	28 tons milk.
Negligible quantity of sugar.	2¾ tons sugar.

The British farmer feeds from 45 to 50 persons per 100 acres, while the German farmer feeds from 70 to 75. [But the German farmer, as Lord Rhondda points out, has a poorer soil and climate].

The comparative value of the produce per acre of British and Belgian land, which closely resembles it as far as natural fertility is concerned, is said to be as 19 : 80. . . . *The explanation of the greater productivity of the German farm* becomes clearly apparent when the consumption of artificial fertilisers is examined. This is shown in the following table:—

Table XII.—*Average Consumption of Fertilisers per Acre.*

	Potash fertilisers (lbs.)	Nitrogenous. fertilisers (lbs.).
Germany	10·68	7·21
France	0·71	3·65
United Kingdom ..	0·09	2·22

It is said that Germany imports about ten times as much Chilian nitrate as the United Kingdom, and one-third of all the nitrate exported is consumed by Germany alone; hence it is hardly surprising that the yield per acre of German farms has nearly doubled in thirty years.

The British Navy stopped all that import, but Germany goes on, *thanks to her appreciation of the genius of British* chemists. The whole thing came out of the Royal Institution in Albemarle Street, with its Faraday, Crookes, and Rayleigh. But the best that their countrymen can do, so far as political wisdom is concerned, is the Corn Production Act, in which the first essential for corn production is totally ignored.

But to return to Lord Rhondda's Introduction, which I largely quote here in the hope that it will serve to compel the reader to study the whole book. Lord Rhondda points out that the splendid genetic work of Professor Biffen *at Cambridge, based on Professor Bateson's Mendelian re*discovery and elaboration, "has resulted in the production

of new varieties of wheat which yield 10 per cent more grain per acre than other variety, and possess also excellent milling and baking qualities of the highest grade wheat from Canada and the United States." Having said so much for "nature," he proceeds to "nurture," citing first the magnificent, decade-long work at Rothamsted, which "has demonstrated that the prime factor in wheat production is a sufficient supply of nitrogenous manure. Yields of wheat exceeding the national average have been reaped from certain of the Rothamsted plots continuously every year for eighty years by judicious cultivation and manuring, and there is at least one instance in this country of successful continuous wheat-growing on the farming scale on Rothamsted lines. Experience gained during the war has further shown that fine crops of cereals can be grown by suitable manuring on newly broken-up grassland without the expense of growing preparatory non-cereal crops. Obviously, the accepted views as to rotation of crops stand in need of revision." After exposing the imbecile superstition of British farmers, that live stock with its by-product farmyard manure is the backbone of wheat production, Lord Rhondda goes on to consider the production of fixed nitrogen from the air, quoting the recent record of Southern Norway and Germany, and the United States. Not, however, that the United States has much to boast about. Last year, according to last evening's paper, they imported 1,494,000 tons of nitrate of sodium —say, one fourth for agriculture and the rest for explosives. And now, it seems, a "Nitrate of Soda Executive" has been appointed here "with a view to ensuring the purchase of adequate supplies in Chili for the British, French, Italian, and United States Governments." Meanwhile, Germany, which imported before the war one-third of all the Chilian output, gets none, and carries on thanks to English brains, whilst our Food Controller has to tell us that "at the present time there is in this country a shortage of artificial fertilisers, chiefly because there is a shortage of freight space. The nitrates are in abundance in Chili, but we need them here and shall increasingly need them." Well may he continue:—

> The attention which can scarcely fail to be directed to this subject by Sir William Crookes's treatise ought now to result in the action which we should have taken a decade ago. We lacked nothing but the foresight and the will; we had the knowledge, we had the power, if not in falling water then in coal. To-day no foresight is required to recognise the need, and necessity is spurring our will. If we are to feed ourselves, we must begin by securing a continual provision of the fixed nitrogen which is necessary to feed our best food, and which we can begin to make for ourselves, in any quantities, whenever we please.

As for the book, to which his attention was first directed in July, 1915,

> it was a pleasure then to undertake the financial responsibility for the revision and republication. That pleasure is not lessened now when the work appears and finds me as Food Controller occupying a post in relation to the nation's food which probably no one could have foreseen when the present revision was undertaken. I shall count myself well rewarded if the reissue of this book may help to increase the production of food within our own shores, and so render more secure our national existence.

What are we coming to? Is Knowledge in Power? A statesman, in the purlieus haunted by Palmerston and Randolph Churchill, paying for the publication of a "damned Professor"; and on the other side of the Atlantic, an ex-Professor of Political Economy already the unchallengeable President of Democracy Militant! Is it possible that Ruskin's dream may be realised, and that some day, after all, the world will be ruled by the "wise and kind"?

LYNX.

ON THE PREPARATION AND HYDROLYSIS OF ESTERS DERIVED FROM THE SUBSTITUTED ALIPHATIC ALCOHOLS.*

By W. A. DRUSHEL and G. R. BANCROFT.

In 1894 de Hemptinne (1), working under the direction of van 't Hoff, determined the velocity constants for the hydrolysis of eleven of the lower aliphatic esters. These included methyl, ethyl, propyl acetates, propionates, butyrates, also ethyl isobutyrate and ethyl valerate. This work of de Hemptinne showed that the unsubstituted alcohol radical has very little influence upon the rate of acid hydrolysis. Later in the same year Löwenherz (2), also under van 't Hoff, determined the velocity constants for the acetates of glycerol and phenol. By a comparison of these results with those obtained by de Hemptinne for methyl, ethyl, and propyl acetates, it was shown that although the alcohol radical has little influence in determining the rate of hydrolysis its chemical nature is of considerable importance.

In 1897 and 1898 Geitel (3) studied the velocities of the hydrolysis of mono-, di-, and triacetates of glycerol when catalysed with decinormal hydrochloric acid at 25° and found them to be in the ratios of 1 : 2 : 3. In 1907 Julius Meyer (4) investigated the reaction velocity of the hydrolysis of ethylene glycol monoacetate and diacetate, working at 25·2° and catalysing the reaction with N/50 and N/100 hydrochloric acid.

The reaction with the glycol diacetate was found to proceed in two stages, the monoacetate being formed as an intermediate product, and this finally decomposing forms ethylene glycol. The rate of hydrolysis in the first stage was determined to be double that of the second stage. E. Abel (5) and R. Kremann (6) have also studied the acid and alkaline hydrolysis of esters of the polyhydric alcohols. Their results seem to agree with those of Geitel in that they found the rate of hydrolysis in the case of tri-, di-, and monoacetates of glycerol to be in the ratio of 3 : 2 : 1.

In 1910 a study of the effect of constitution on the rate of ester hydrolysis was begun in Kent Chemical Laboratory of Yale University. A series of articles (7) dealing with the hydrolysis of esters of substituted aliphatic acids has already appeared. In this paper, and others which may follow, the investigation is concerned with the study of the effect of substitution in the alkyl radical of an ester upon the rate of hydrolytic cleavage.

Preparation of Materials.

The α-chlor-ethyl acetate was prepared by the method of Simpson (8), by heating equimolecular quantities of acetyl chloride and water-free acetaldehyde in a sealed tube at 100°. The ester, boiling at 120°-124°, was purified by fractionation. As a further criterion of purity it was analysed for halogen. Weighed portions of the ester were hydrolysed with sodium hydroxide on a steam-bath. The formation of aldehyde resin indicated the presence of acetaldehyde. After filtering off and carefully washing the resin, the filtrate was neutralised with nitric acid and the halogen estimated by titrating with decinormal silver nitrate, using potassium chromate as an indicator.

Chlorine found—I. 28·27 per cent; II. 28·62 per cent.
Chlorine calculated—28·94 per cent.

The α-chlor-ethyl propionate was prepared by the method of Rubencamp (9). Equimolecular portions of water-free acetaldehyde and propionyl chloride were heated in a sealed tube at 120°. The ester, boiling at 134°-136°, was purified by fractionation and its halogen content was shown to correspond to theory using the method outlined above for the α-chlor-ethyl acetate. Here, as in the preceding case, aldehyde resin was formed in the hydrolysis.

The α-ethoxy-ethyl acetate was obtained (10) by heating

* From the *American Journal of Science*, xliv., p. 371.

equimolecular portions of the diethyl acetal of acetaldehyde and acetic anhydride in a sealed tube at 150°. The reaction product was washed with a solution of potassium carbonate, then separated and dried over freshly fused potassium carbonate. That portion distilling over at 125°-130° was collected as the pure ester. The acetal from the above preparation was prepared by the method of Fischer and Giebe (11).

As a preliminary to the preparation of the β-substituted esters the following compounds were prepared in considerable quantity: ethylene dibromide, ethylene glycol diacetate, and ethylene glycol. The ethylene dibromide was prepared by the method of Balard (12). The ethylene glycol diacetate was obtained by refluxing a mixture of one mol. of ethylene dibromide with two mols. of fused anhydrous potassium acetate in the presence of a mol. of glacial acetic acid (13). A second method (14) was also used in the preparation of the glycol diacetate. One mol. of ethylene dibromide and two mols. of freshly fused potassium acetate were refluxed in a solution of eighty-five per cent alcohol on a water-bath for eighteen to twenty hours, and filtered to remove the potassium bromide. The filtrate was fractionated to remove the alcohol and the glycol diacetate was collected at 185—187°.

The ethylene glycol was produced by the hydrolysis of ethylene glycol diacetate according to the method of Haller (15), the process being carried out as described by Louis Henry (16), and the yields corresponded to those given by Gattermann (17).

β-Hydroxy-ethyl acetate was first prepared by Atkinson (18) by heating on a boiling water-bath for two days equimolecular quantities of ethylene dibromide and potassium acetate in a solution of 85 per cent ethyl alcohol. De Mole (19) claimed a considerable yield of the monoacetin of ethylene glycol by heating for eighteen hours at the boiling temperature an equimolecular mixture of ethylene dibromide and freshly fused potassium acetate in an 80 to 85 per cent solution of ethyl alcohol. Lourenço (20) obtained this ester by heating equimolecular quantities of ethylene glycol and glacial acetic acid for one day in a sealed tube at 200°.

The above method of Atkinson and De Mole was employed with the hope of obtaining the β-hydroxy-ethyl acetate. 300 grms. of ethylene dibromide were treated with 155 grms. of water-free potassium acetate in 300 grms. of 85 per cent ethyl alcohol. This mixture was digested for twenty hours in a flask fitted with a reflux condenser on a boiling water-bath. The potassium bromide which precipitated was filtered off, and the filtrate fractionated to remove the alcohol. A yield of 83 grms. of diacetate was obtained, but no monoacetin was formed, as no reaction took place on treatment of a portion with acetyl chloride.

On treating 300 grms. of ethylene dibromide with 310 grms. of anhydrous potassium acetate in 300 grms. of 85 per cent ethyl alcohol, digesting for twenty-four hours, filtering, and fractionating the filtrate, a yield of 174 grms. of glycol diacetate was obtained. This result is in accordance with the experience of Louis Henry (21), who states that the diacetate is obtained by treating ethylene dibromide with fused potassium acetate, as described above. This method was tried repeatedly, always with the same result, and the product was used in the preparation of ethylene glycol. Also on saturating a portion of the product with dry hydrobromic acid gas the β-brom-ethyl acetate was formed.

Finally, a direct esterification method was devised for the preparation of the β-hydroxy ethyl acetate, which is really a modification of that given by Lourenço (22), to which reference has already been made. Equimolecular portions of ethylene glycol and glacial acetic acid were digested over twice the theoretical quantity of anhydrous copper sulphate in a flask over a free flame for eight hours. In order to keep track of the esterification, 1 cc. of the reaction mixture was pipetted into a graduated flask before heating and the volume made up to 250 cc. Aliquot portions of 50 cc. were withdrawn and titrated with decinormal sodium hydroxide. Other portions of the reaction mixture were withdrawn from time to time and treated as described above. At the end of eight hours the titration showed that the esterification was practically complete. The esterified mixture was cooled and decanted, and the copper sulphate residue was extracted with ether. The mixture was then fractionally distilled, the main portion coming over at 185—190°, and on refractionating boiled at 187—189°. This portion reacted vigorously with acetyl chloride, effervescing briskly with evolution of hydrochloric acid gas.

Weighed portions of this ester were placed in flasks and saponified with an excess of decinormal sodium hydroxide, according to the following equation:—

$$\begin{array}{l} CH_2OH \\ | \\ CH_2.O.CO.CH_3 \end{array} + NaOH \rightarrow \begin{array}{l} CH_2OH \\ | \\ CH_2OH \end{array} + CH_3.CO.ONa$$

The excess of sodium hydroxide was then titrated with decinormal hydrochloric acid using phenolphthalein as an indicator. From results obtained the ester was shown to be 99·38 per cent pure.

The use of anhydrous copper sulphate as a dehydrating agent (23) in the esterification of certain hydroxy-acids has been previously described in the literature. In the present investigation this dehydrating agent is used for the first time in the esterification of polyhydric alcohols.

Another point worthy of mention in connection with the preparation of this compound is the low boiling point given by the various investigators. Atkinson gives 182°, De Mole 180—182°, and Lourenço 180°, as the boiling point of their respective products. Glycol diacetate boils at 186—187° and ethylene glycol at 197°. From the molecular constitution of the monoacetin of ethylene glycol we would naturally expect its boiling point to lie between those of ethylene glycol and glycol diacetate. The boiling point of the main portion of the product obtained by direct esterification was distinctly higher than that given in the literature, and lies between that of the glycol and of the diacetate.

The β-methoxy-ethyl acetate was prepared by treating the β-methoxy-ethyl alcohol with the theoretical quantity of acetyl chloride. The ester, boiling at 144—145°, was purified by fractional distillation. This ester has been previously prepared (24) by treating the corresponding alcohol with acetic anhydride.

The β-methoxy-ethyl alcohol was obtained for the preparation of the β-methoxy-ethyl acetate by preparing monosodium glycollate, and treating it with the theoretical quantity of methyl iodide under suitable conditions according to the method of Palomaa (25). A separation of the glycol-ether, boiling at 124—126°, was effected by fractionation.

The β-ethoxy-ethyl acetate was prepared by treating β-ethoxy-ethyl alcohol with acetyl chloride. The excess of acetyl chloride was removed by fractional distillation, and the ester was found to boil at 157—158°. The alcohol used in this preparation was obtained by the method of Palomaa. The monosodium glycollate was treated with ethyl iodide as described in this method. Upon fractionation the alcohol distilled over at 134—135°, and possessed the properties given by Palmomaa (26) and De Mole (27).

The β-ethoxy-ethyl alcohol was also obtained by a second method which is not recorded in the literature, and appears here for the first time. In attempting to prepare β-ethoxy-ethyl acetate by refluxing equimolecular quantities of β-brom-ethyl acetate and sodium ethylate, it was found that β-ethoxy-ethyl alcohol was obtained. The materials were refluxed in a water-free alcoholic solution for half an hour on a water-bath. On filtering from sodium bromide and fractionating the reaction mixture, a product was obtained which had all the physical characters of the β-ethoxy-ethyl alcohol. It also reacted with acetyl chloride giving the β-ethoxy-ethyl acetate.

The β-chlor-ethyl acetate was prepared by treating ethylene chlorhydrin with acetyl chloride (28) in slight excess of the theoretical amount. The pure ester, boiling at 143—145°, was obtained by fractionation. The β-ethylene chlorhydrin for the preparation of this ester was obtained according to the method of Ladenburg (29). This ester was analysed for halogen as a further test of the purity of the substance.

Chlorine found—I. 28·40 per cent; II. 28·18 per cent; III. 28·34 per cent.
Chlorine calculated—28·94 per cent.

The β-brom-ethyl acetate was obtained by the method of Louis Henry (30), which is essentially the same as that described by De Mole (31), who treated his monoacetin of ethylene glycol with hydrobromic acid to obtain this ester. Ethylene glycol diacetate was saturated with dry hydrobromic acid gas, and the resulting product was fractionated. The boiling-point and specific gravity of the purified ester corresponded to the values given in the literature. The halogen content of the ester was also determined by analysis.

Bromide found—I. 47·56 per cent; II. 47·56 per cent; III. 47·50 per cent.
Bromine calculated—47·86 per cent.

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(To be continued).

THE NITRATE SITUATION.

By G. BASIL BARHAM, C.E.

The discovery was made, a few weeks ago, that the supply of nitrates in America was dangerously low. The need for using shipping to better advantage shut off the supplies from Chile, and it was realised that steps must be taken immediately to remedy the shortage or a serious position would result. The engineers of one of the largest Trans-atlantic chemical firms were called upon, a site of 2200 acres was obtained, and work was commenced immediately in connection with the erection of one of the largest nitrate plants yet laid down. The size of the works may be realised when it is mentioned that the cost will exceed 30 million dollars, exclusive of the cost of raising the huge dam necessary to provide the water-power for generating the required electricity. The latter part of the work will take up more time than the laying down of the plant, and so overhead mains are being erected to carry 30,000 horse-power in electrical energy from one of the big power companies. A steam-power plant of 30,000 horse-power is also being erected. No expense is being spared as regards labour, and it is estimated that in three or four months' time the manufacture of nitrates will be in full swing. The shortage has had the important effect of emphasising the necessity which exists for developing on a large scale, not only in America, but in every other country, the essential means for obtaining nitric acid from the air through the erection of nitric acid plants for the fixation of atmospheric nitrogen.

This process of producing nitrates has been in use for some time in Germany, and that country, although cut off from the Chilean fields by British sea power, has been able to make all the nitric acid she has required for the manufacture of high explosives and for the making of fertilisers. Nitrate of lime and soda have been manufactured there for a considerable time, and whilst it is not easy to ascertain to what extent German chemists have developed the various processes they were working at the time war broke out, it is practically certain that considerable improvements have been effected on the methods then in vogue. At that time it was estimated that something over 1000 tons of nitrates could be produced annually per 2000 electrical horse-power available.

British Pioneers.—The processes referred to are those which are connected with the obtaining of nitric acid from the air by means of electrical energy, and are summed up under the heading of methods for the fixation of atmospheric nitrogen. Most of the large works at which this work is done are on the Continent, and this, in spite of the fact that by far the greater part of the pioneer work was carried out in this country by British engineers and chemists, such as Dr. Priestley, Lord Rayleigh, Sir William Crookes. At the time war broke out the Norwegian plants alone for the manufacture of calcium nitrates from the air aggregated some 200,000 horse-power, and if estimates formed at that time have been justified the extensions should be such that they amount by this time to two or even three times that capacity. These Norwegian concerns, and a large number of the German chemical works are using either the Birkeland-Eyde process itself or the modification of it, which was first brought into use by the German Badische Anilin und Sodafabrik. In addition to these there are the Pauling and the Schönherr processes, as well as a number of specialised methods of manufacturing calcium cyanamide, graphite, calcium carbide, &c. At the time mentioned this vast field was untouched in England, with the exception of a comparatively small plant which has been laid down at Thornton on the mains of the Yorkshire Power Company, for the manufacture of calcium carbide. At that time, however, thanks to the studied care with which German chemists manipulated their output of artificial nitrates, the price was low, and there seemed no likelihood of a shortage. In this, as in connection with so many other manufactures, it was felt to be cheaper and better

business altogether to buy from the Germans or from the firms in which they were interested, than to manufacture for ourselves, at a somewhat higher cost.

The Electrical Method.—There are a number of methods by which atmospheric nitrogen may be obtained on a commercial scale, such as the conversion of nitrogen direct into nitric acid, the synthesis of ammonia and ammonium compounds from the air, and the conversion of atmospheric nitrogen into compounds which can be made to yield up their ammonia content when required. Commercially, the first is the most satisfactory method, and it is generally carried out by causing the nitrogen and the oxygen of the air to unite by means of an electric discharge.

The Birkeland-Eyde process, to which attention has already been called, is generally considered to be the most economical and efficient of all those which have for their object the oxidation of nitrogen, and it is interesting to note that the process is in itself merely a successor to the experiments which were carried out in the eighteenth century by the English scientist, Cavendish. He was the first to produce a combination between the nitrogen and the oxygen of the atmosphere by forcing electrical discharges to pass through the air during the decomposition of a quantity of alkali, and so obtain nitric acid. In principle, the Birkeland-Eyde process is similar, although, of course, certain modifications have been made and certain new auxiliary methods have been introduced.

The Manufacturing Process.—The electric furnace, which is the fundamental element of the whole process, is so constructed that the air admitted becomes heated to a very high temperature. An alternating current at about 5000 volts forms an arc between two electrodes, and this arc is acted upon by an electro-magnet so as to lengthen it to the extreme limits of tenuity. In this way greater surface is available, and the effect of the electrical discharge on the air admitted is enhanced.

The flame actually assumes a disc form in some types of the apparatus, and the air is forced to sweep past this on either side. The nitrogen becomes oxidised at once, and the gas, which leaves the furnace, only requires cooling, cleaning, and concentrating.

To enable this to be carried out the gas is led to a series of oxidisation towers, from which it passes to the absorption towers, which are built partly of stone and partly of wood, and in which the gas is passed over limestone sprinkled with water. All that has to be done then is to concentrate the product, and this is carried out in large pans, first by the aid of steam, and later by direct heating with coal. The mass is steamed to a fusing point of 145 degrees, and is thereafter poured into tin cylinders where it solidifies as it cools. In this form the nitrate is sold to manufacturers of fertilisers, by whom it is broken to powder and mixed with other substances as desired. The finished product contains about 12½ per cent of nitrogen and possesses all the fertilising properties of Chilean saltpetre.

The Pauling and the Schönheer processes are closely similar, and it may be mentioned that in technical furnaces the arc formed is frequently 21 feet in length. The gases leaving the furnace contain only about 2 or 2½ per cent of nitric oxide, so it will be seen that the concentration process is one of importance. But there is nothing difficult about the work, and the only fact that has militated against its employment since the war has been the expense of electrical energy. But in view of the present situation no question of expense should be allowed to stand in the way of establishing at once plants for the manufacture of nitric acid in this country.—*The Globe*, February 26, 1918.

Appointment.—Prof. Sir J. J. Thomson, O.M., F.R.S., has been installed as Master of Trinity College, Cambridge, in succession to the late Dr. Butler.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, February 14, 1918.

Sir J. J. Thomson, O.M., President, in the Chair.

Papers were read as follows:—

"*The Artificial Production of Echinoderm Larvæ with two Water-Vascular Systems, and also of Larvæ Devoid of a Water-Vascular System.*" By Prof. E. W. MacBride, F.R.S.

In Echinoderm larvæ the change from bilateral to radial symmetry is due to a series of changes which are ushered in by the appearance of a small bud, termed the hydrocœle, on the left side of the larvæ. This bud is the rudiment of the water-vascular system of the adult. A number of instances have been recorded where, in an isolated specimen, a similar bud has appeared on the right side also, and the whole subsequent history of the larvæ has been altered.

The present communication describes a method for inducing the formation of a second hydrocœle. By exposing the larvæ to the action of hypertonic water at a certain critical period of their development, and by subsequently removing them to extremely favourable surroundings, in so far as concerns both food and space, it is possible to secure that a certain percentage of them will possess two hydrocœles. The development of the second hydrocœle may begin earlier or later. If it begins earlier the organs found in the normal larvæ on the right side (pedicellariæ) will not be formed, but if it begin later one or more of these organs may be formed.

If larvæ be starved for the first week of their existence and then transferred to good conditions as to food and space, the formation of both hydrocœle and pedicellariæ will be inhibited, and larvæ perfectly bilaterally symmetrical will be produced which are provided on each side with a group of pointed spines in place of both dyhrocœle and pedicellariæ. From this observation it seems to follow that the formation of pedicellariæ is dependent on the presence of a hydrocœle bud, so that this bud tends to induce the formation of pedicellariæ on the opposite side of the larvæ, and to inhibit their formation on the same side as itself.

The formation of a hydrocœle bud on the right side involves profound modifications of the surrounding tissues. These tissues are forced to pursue a course of development totally foreign to anything that has been normal in the history of the race. In conclusion, the bearing of the facts adduced on the nature of the laws governing the building up of the bodies of embryos and larvæ is discussed.

"*Quantitative Differences in the Water-Conductivity of the Wood in Trees and Shrubs.*" By Prof. J. B. Farmer, F.R.S.

The paper deals with the efficiency of the wood regarded from the standpoint of water-conductivity. About sixty species of plants, chiefly trees and shrubs, have been investigated. The method adopted consists in determining the amount of water passing in fifteen minutes, delivered at a head of 30 cm. of mercury through each square cm. of wood of 15 cm. in length.

The results show that wide differences exist between different species but that for a given species there is commonly an ascertainable mean. Evergreens as a class are characterised with wood of low conductivity with often small absolute fluctuation. Deciduous adult trees and shrubs always possess wood of relatively high conductivity, but the sapling trees and stool shoots of coppiced woods exhibit low conductivity in their wood, even when that of the adult shoots is high. The results are of significance in throwing light on an aspect of xerophily and of transpiration which has hitherto been disregarded. It is

also shown that the dying back of the leaders in some trees (*e.g.*, ash) is correlated with the character of their wood.

The sap wood of deciduous trees commonly fills up with water during the early autumn, and grounds are shown for observing caution in fitting conclusions reached in other climates to the circumstances that obtain in the British Isles. This matter is of some importance in its bearing on the conditions that affect the seasoning of timber.

"*Efficiency of Muscular Work.*" By Capt. M. Greenwood.

It is shown that the relation between total heat production, body mass, and external work can be expressed with sufficient accuracy for interpolation by a function of the first degree, the constants of which have been determined from the data by the method of multiple regression. The method is illustrated upon the data of Macdonald and those of Amar. When body mass is constant, the relation is $H = aW + b$, H being total heat production, W the thermal equivalent of the work, a a constant, and b a variable parameter dependent on the speed of work performance. The parameters are calculated for the data of Benedict and Cathcart. It is pointed out that the relation necessarily involves an increase of efficiency with amount of work when efficiency is defined as W/H or as W/(H - *h*), *h* being the "basal" heat production, and that this increase may be without biological significance. Reasons are given for doubting whether the general relation between heat production and muscular efficiency can be safely inferred from existing series of observations, and economy of thermogenesis is discussed.

PHYSICAL SOCIETY.

Annual General Meeting, February 8, 1918.

Prof. C. V. Boys, F.R.S., President, in the Chair.

The Annual Report of the Council was taken as read.

The Treasurer's Report was read by Mr. W. R. Cooper.

Both reports were unanimously adopted.

Votes of thanks to the Honorary Auditors, the Officers and Council, and the Governing Body of the Imperial College were carried unanimously, the respective proposers and seconders being Messrs. C. C. Paterson and T. Smith, Mr. S. D. Chalmers and Dr. Bryan, Dr. H. S. Allen and Mr. F. Whipple.

The Scrutators (Mr. J. Lister and Mr. A. W. Grace) announced that the Officers and Council for the ensuing Session as proposed on the balloting list had been unanimously elected. These are :—

President—Prof. C. H. Lees, D.Sc., F.R.S.

Vice-Presidents (who have filled the office of President—Prof. G. C. Foster, F.R.S.; Prof. R. B. Clifton, M.A., F.R.S.; Prof. A. W. Reinold, C.B., M.A., F.R.S.; Sir W. de W. Abney, R.E., K.C.B., D.C.L., F.R.S.; Prin. Sir Oliver J. Lodge, D.Sc., F.R.S.; Sir R. T. Glazebrook, C.B., D.Sc., F.R.S.; Prof. J. Perry, D.Sc., F.R.S.; C. Chree, Sc.D., F.R.S.; Prof. H. L. Callendar, M.A., F.R.S.; Prof. A. Schuster, Ph.D., F.R.S.; Sir J. J. Thomson, O.M., D.Sc., F.R.S.; Prof. C. Vernon Boys, F.R.S.

Vice-Presidents—Prof. J. W. Nicholson, M.A., D.Sc., F.R.S.; Prof. O. W. Richardson, M.A., D.Sc., F.R.S.; S. W. J. Smith, M.A., D.Sc., F.R.S.; W. E. Sumpner, D.Sc.

Secretaries — W. Eccles, D.Sc., City and Guilds Technical College, Leonard Street, E.C. 2; R. S. Willows, M.A., D.Sc., the Sir John Cass Technical Institute, Jewry Street, Aldgate, E.C.

Foreign Secretary—Sir R. T. Glazebrook, C.B., D.Sc., F.R.S.

Treasurer—W. R. Cooper, M.A., B.Sc., 82, Victoria Street, S.W. 1.

Librarian—S. W. J. Smith, M.A., D.Sc., F.R.S., Imperial College of Science and Technology.

Other Members of Council—H. S. Allen, M.A., D.Sc.; Prof. E. H. Barton, D.Sc., F.R.S.; C. R. Darling, F.I.C.; Prof. G. W. O. Howe, D.Sc.; D. Owen, D.Sc.; C. C. Paterson; C. E. S. Phillips, F.R.S.E.; S. Russ, M.A., D.Sc.; T. Smith, B.A.; F. J. W. Whipple, M.A.

The President announced that Dr. R. S. Willows, M.A., was resigning his Secretaryship, on leaving London for a post in the North. The Council had appointed Dr. H. Stanley Allen, M.A., in his place.

At the conclusion of the general business, Prof. Boys vacated the Chair, which was taken by his successor, Prof. C. H. Lees, F.R.S.

A paper on "*A Recording Thermometer*" was read by Prof. C. V. Boys.

This instrument was designed and constructed to go into the case of a regulator clock. The thermometric element consists of a rod of ebonite within a glass tube. The differential expansion is determined by a pair of levers giving a movement of 1 in. for 10° F. The drum carries an ordinary barometer chart, and is driven at such a speed that a two-hour interval of ½ in. is passed in twenty-four hours. The drum is driven by friction by means of a cord from below the driving weight of the clock by an $e^{\mu\theta}$ arrangement, in virtue of which when the clockweight descends the drum turns, but when the clock is wound the drum remains at rest. The instrument is designed with a view to easy construction and accuracy. It is extremely rigid, and much more magnification might be used.

An alternative design on the same lines to go into a recording baragraph is also given.

Discussion.

Mr. C. C. Paterson said that for certain purposes a quick-acting sensitive recording thermometer was very useful. What was the time lag of this instrument in taking up the temperature of the surroundings?

Prof. Lees asked how the ebonite behaved as regards constancy.

Prof. Boys, in reply, said that for his purpose the thermometer was desired to be slow and sluggish, so as not to take up every trifling variation of temperature due to people entering the room. To make it quick-acting, a thin strip of ebonite would have to be used, and the glass tube should be replaced by a stout glass rod or plate some distance from the ebonite. As regards constancy, he could only speak for the three months that the instrument had been in use. There had been no signs of variability in that time.

A paper, entitled "*The Primary Monochromatic Aberrations of a Centred Optical System,*" was read by Mr. S. D. Chalmers, M.A.

The paper describes approximate methods of treatment of the first order aberrations of a centred optical system. Two methods are used, one primarily suited to the case where the separation of the surface is small, and the other more suited for use where the separations vitally affect the design.

The aberrational defects are expressed as lateral aberrations; *i.e.*, as defects measured in the focal plane of the system. The procedure adopted is to express the aberrational defect of a single surface in terms of the constants of the surface, and the perpendicular distance of the ray considered from the centre of curvature of the surface. The value of this perpendicular can be expressed in terms of the co-ordinates of the ray in any chosen medium, and thus the aberration due to each surface can be expressed in terms of the co-ordinates of the chosen ray, in such a way that the aberrations of the individual surfaces can be summed.

Discussion.

Mr. T. Smith congratulated the author on his paper, which he considered an interesting and valuable addition to the existing discussions on optical aberrations. He had himself used a similar reference system in dealing with this subject, but in place of a partially geometrical discussion had preferred to use a purely analytical method. The

geometrical treatment was obviously advantageous in giving an insight into the mysteries of aberration to students, but it was very difficult to be certain that every contributory cause had been considered. The results stated in the paper were correct, but he was not clear that one possible contributory cause, which happened to this approximation to give a zero contribution, had received adequate consideration. If in a system of refracting surfaces at some intermediate theoretical image plane an aberration δy were present, the corresponding effect in the final image plane should not be assumed to be $m\delta y$, where m is the first order magnification which the image subsequently undergoes. The exact co-ordinates to the second approximation $y+\delta y$, and the exact magnification to the same order $m+\delta m$ should be considered, so that the final co-ordinates to this order are $my+y\delta m+m\delta y$. It can be shown that when all the surfaces are taken into consideration the contribution of the type $y\delta m$ is zero. He thought that the paper could with advantage consider this point more fully. An interesting question which arose in connection with the analysis of refraction into displacements according to the ordinary laws of geometrical optics with aberrations superposed, related to the limits within which such a procedure was justifiable. The ordinary laws could only be taken as a possible first approximation for all rays for refractive indices exceeding 3. Instead of an incident angle in air of a right angle, the first approximation may only be used up to an incident angle of $\cos^{-1}\frac{3-\mu}{2\sqrt{2}}$. As the index falls in value the range over which the approximation holds becomes less, and in the limiting case when $\mu=1$, the range is from 0° to 45° compared with the range 0° to 90° over which refraction takes place.

Prof. LEES said that these methods appeared to start off from the approximate assumption that the image of a plane was a plane. Did not this lead to errors comparable with those which were being dealt with?

Mr. CHALMERS replied as follows:—The criticisms made by Mr. Smith are not, I think, justified, because the terms to which he refers do not arise in the method of treatment adopted. In transferring the aberration to the last medium it is permissible to multiply by the paraxial magnification since the actual point of crossing the object plane is transferred to the image plane by multiplying its co-ordinates by the paraxial magnification, and adding aberrational defects for this surface for the actual ray. This aberrational defect is expressed in terms of the modified values of the co-ordinates, but as the modifying terms are multiplied by the small aberrational terms this introduces terms of higher order only. If it be necessary to consider terms of higher order, it would be necessary to take them into account in expressing values of the p's in terms of the co-ordinates in the initial medium.

Mr. Smith's remarks on limits to which approximation could be applied are very interesting; they show that approximations are justified in practically all cases which arise, except for a few cases of refraction at plane surfaces, and in this case the term he quotes is multiplied by a zero curvature.

INSTITUTE OF CHEMISTRY.

Annual General Meeting, March 1, 1918.

SIR JAMES DOBBIE, the retiring President, said that the past three years had afforded unusual opportunities for demonstrating the utility of the Institute, and the special services which it had rendered in connection with the war had been widely acknowledged. It had done very valuable work in introducting suitable candidates for commissions in His Majesty's Forces where technical knowledge and experience were required, and in providing chemists for Government factories, controlled establishments, and laboratories engaged in war work. Every public department and every branch of the fighting services that required the aid of the chemist had made use of its services, and in this connection the names of thousands of chemists of various grades had passed through its registers. The Institute might fairly claim to have been the chief agent in mobilising the chemists of the country for war purposes.

Further, since the beginning of the war the Institute had been unremitting in its efforts to ensure to chemists a supply of pure reagents, glass, and porcelain. The value of the glass research work carried out under its auspices had been recognised on all hands, and with the aid of the Department of Scientific and Industrial Research the investigations originally undertaken for purely chemical purposes had been extended for the benefit of nearly every branch of the glass industry.

The attention of the Council, however, had been very largely devoted to the revision of the regulations for admission to the membership of the Institute, with a view to promoting the more complete organisation of British professional chemists. He hoped that means would be found of constituting the Institute the representative body of all properly qualified professional chemists, and that it should also undertake to maintain a register for others who were engaged in chemistry, but were not necessarily qualified for admission to the Institute as members. Such an organisation as they had in view would make it possible, when occasion demanded, for the chemists of the country to bring their whole weight and influence to bear on questions of national interest.

A number of motions referring to the Regulations for the admission of members of the Institute were on the Agenda in the names of Messrs. J. H. Lester and W. Marshall (Manchester), and Mr. W. Gathorne Young (Doncaster), but were withdrawn on the understanding that an opportunity would be given for a full discussion at an Extraordinary General Meeting of the Institute to be held in the near future.

The Officers and Members of Council for the ensuing year were elected as follows:—

President—Sir Herbert Jackson, K.B.E., F.R.S.

Vice-Presidents — Horatio Ballantyne; Oscar Lisle Brady, D.Sc.; William Thomas Burgess; Charles Frederick Cross, B.Sc., F.R.S.; Sir James J. Dobbie, LL.D., D.Sc., F.R.S.; Arthur Harden, D.Sc., F.R.S.; Sir Robert Robertson, K.B.E., D.Sc., F.R.S.

Hon. Treasurer—Alfred Gordon Salamon, A.R.S.M.

Members of Council—Edward Charles Cyril Baly, F.R.S.; Charles Olden Bannister, A.R.S.M.; Hugh Charles Herbert Candy, B.A., B.Sc.; Alfred Chaston Chapman; Cecil Howard Cribb, B.Sc.; John Thomas Dunn, D.Sc.; Ernest Mostyn Hawkins; George Gerald Henderson, M.A., D.Sc., LL.D., F.R.S.; Patrick Henry Kirkaldy; Harold George Lacell, A.R.C.S.; Alexander Lauder, D.Sc.; Joseph Henry Lester, M.Sc.; Frederick James Lloyd; William Macnab; Gilbert Thomas Morgan, D.Sc., F.R.S.; Dudley Northall-Laurie; George Henry Perry, M.B.E., B.Sc., A.R.C.S.; Francis Martin Potter, M.B.E., B.Sc., A.R.C.S.; William Rintoul; Harry Silvester, B.Sc.; George Stubbs, O.B.E.; Jocelyn Field Thorpe, C.B.E., D.Sc., F.R.S.; Thomas Tickle, B.Sc.; Leonard Ellerton Vlies; Edmund White, B.Sc.; William Maurice Gathorne Young.

SOCIETY OF GLASS TECHNOLOGY.

Ordinary Meeting, February 20, 1918.

FRANK WOOD, B.Sc., F.I.C., President, in the Chair.

THE following paper was read:—

"*Some Notes on American Practice in the Glass Industry.*" By H. H. PITT.

The author has considerable knowledge of the working of English, Continental, and American glass houses, and the subject matter of his paper dealt largely with information accumulated during a recent visit to the United States.

The American method of producing cut-glass ware in moulds was described first of all, and several articles were exhibited. The interior of each article is fine polished by jets of flame under pressure, the outside being kept cool either by leaving in the mould or by removing and subjecting to an air blast. In all works in the States great care is exercised in keeping presses and moulds in first-class condition, and much of the success achieved must be attributed to this. Neglect of presses and moulds in many English factories leads to dire results. In American glass works the men worked under ideal cooling conditions, and the comfort of the worker before the furnace was ensured by very large air cooling dences. Lantern slides depicting the interior of several American glass houses were most instructive. In some factories systems of intermittent working are in vogue, the men having rest periods between spells of work. This is said to increase output and at the same time render the work less irksome.

Detailed descriptions were given of various types of pressing and blowing machines, and good lantern-slides were also shown. The Owens bottle making machine received very full treatment, and the whole of the works practice, from the mixing of the batch to the packing of the finished bottle, was described in detail. The arrangement of a factory using the Westlake bulb-blowing machine was also fully described, and the fact was pointed out that this machine worked from a special pot into which metal was laded from actual melting pots.

Not the least interesting portion of the lecture was a description, illustrated by slides, of the various methods of making sheet-glass by machinery.

The next meeting of the Society will be held on March 20 at Newcastle.

OBITUARY.

THOMAS TYRER, F.I.C.

AT Golder's Green, on February 25, another of the great men who have helped to raise industrial chemistry in this country to its present standard was cremated with the most impressive simplicity in the presence of many friends in the scientific and industrial world.

Thomas Tyrer, who passed away suddenly on February 21 at his residence, 14, Sandwell Mansions, Hampstead, was a cosmopolitan personality in the chemical world, and was closely identified with the commercial and industrial side of chemistry for the last fifty-five years.

Born in the hardware town of Wolverhampton in 1844 he was educated at his father's school. At the age of fifteen he was apprenticed to a chemical manufacturer in Wolverhampton. In 1861 he entered the Royal College of Chemistry in Oxford Street (incorporated with the Royal School of Mines), where he studied under the late Prof. Hofmann, and among his fellow students were a great number of famous chemists. He studied biology under Huxley and physics under Tyndall.

It became necessary for young Tyrer to earn his own living, and therefore his studies were interrupted, and in 1862, after passing a rigorous practical test of his abilities as a works chemist, he was engaged by the firm of May and Baker, manufacturing chemists in Battersea, of which he subsequently became a partner, where, in spite of his arduous duties, he found time to lecture on chemistry to a working men's institute. After that his life was devoted to the production of pharmaceutical and technical chemicals. As Managing Director of Messrs. Thomas Tyrer and Co., Ltd., Stirling Chemical Works, Stratford, he was a most liberal and just employer, rewarding men for new ideas and improvements, however trivial, thus encouraging his workers.

In 1881 he, together with a number of other distinguished chemists, founded the Society of Chemical Industry, and from that date onwards up to a few hours before his death he took the very deepest personal interest in the affairs of this great Society, numbering about 5000 British and American members. For the first ten years he acted as Hon. Metropolitan Secretary, and later as Chairman of the London Section, then as President and up to his death as Hon. Treasurer, and he was always one of the most active members of the publication committee.

Thomas Tyrer was identified since its inception with the Institute of Chemistry. As Chairman of the Chemical Section of the London Chamber of Commerce he directed the movement, begun in 1866, so beneficial to the export drug trade of this country and her Colonies. He devoted many years of his life in agitating for free use of untaxed alcohol for industrial purposes, and as a member of the Departmental Committee on Industrial Alcohol was instrumental in furthering the desired object. In 1904 together with his son, C. T. Tyrer, he rendered valuable service in the arrangement of the Chemical Section of the St. Louis Exhibition.

Needless to say Mr. Thomas Tyrer was a member of many learned and scientific societies, and had occupied many important positions in the scientific and commercial world. Thus, he was Past-President of the Society of Chemical Industry and of the British Pharmaceutical Conference, Chairman of the Chemical Section of the London Chamber of Commerce, Hon. Treasurer of the Society of Chemical Industry and of the International Congress of Applied Chemistry. He was on the Board and Executive of the National Physical Laboratory; he had a seat on the Council of the Association of British Chemical Manufacturers, &c.

The late Thomas Tyrer was an enthusiastic and arduous war worker. In 1913 he had already started on a large scale the manufacture of Cellon aeroplane dope, and later he erected a model and one of the best equipped factories in this country for this purpose, thus rendering considerable help to supply this important war material. At the beginning of the war he was elected a member of the Committee appointed by the Board of Trade, the Society of Chemical Industry, and the London Chamber of Commerce to consider and advise as to the best means for obtaining supplies of chemical products and colours, &c.

In recognition of his many services to British chemical industry Mr. Thomas Tyrer received many honours.

In 1891 members of the Chemical Society, Pharmaceutical Society, Society of Chemical Industry, and London Chamber of Commerce, under the Presidency of the late Sir Frederick Abel, presented him with a silver salver and a purse of gold.

In 1905 a similar honour was again conferred upon him. An Address and silver tray and tea and coffee service was presented to him in recognition of "esteem and gratitude for the arduous, unselfish, and disinterested manner in which he has worked for many years to the benefit of the chemical industry in the United Kingdom, with which his name is so prominently associated, and especially for the efforts to obtain untaxed alcohol for industrial purposes."

In 1910 the medal of the Society of Chemical Industry was awarded to him for his distinguished services to chemical industry.

Mr. Thomas Tyrer took the greatest interest in the subject of national education and all that promoted the moral and material advancement of the community, and was devoted to literature and music.

In private life the late Thomas Tyrer was one of the most liberal, unselfish, amiable, and kindest of men, whose only ambition in life was to do good to others. His name will remain deeply engraved in many a chemist's heart who derived help and support from him. He was a most devoted husband; Mrs. Tyrer, who died a few years ago after almost fifty years of married life, having aided him nobly through his career.

He leaves one son, Lieut. C. T. Tyrer, R.N.V.R., and a daughter, Mrs. Thomas.

NOTICES OF BOOKS.

A Text-book of Inorganic Chemistry. Edited by J. NEWTON FRIEND, D.Sc., Ph.D., F.I.C. Vol. IV. *Aluminium and its Congeners, including the Rare Earth Metals.* By H. F. V. LITTLE, B.Sc. (Lond.), A.R.C.S., D.I.C. London: Charles Griffin and Co., Ltd. 1917. Pp. xx+485. Price 15s. net.

THE inorganic chemistry of the elements of the third group of the Periodic Table is fully treated in this volume, together with that of cerium and the rare earth metals. A long chapter is given to clays and ceramics, the preparation of ceramic bodies being described in considerable detail. More than half the volume is devoted to the rare earths, the treatment of which the author claims to be the most comprehensive in the English language. He has collected his material from the standard works on the subject in other languages, and also from original memoirs, and very copious references are given to the abundant literature of the rare earths. The nature of the cathodic phosphorescence spectra is discussed very fully, and many excellent diagrams of spectra are included, and tables of the chief arc and spark spectra of the rare earth elements. For workers in this region the book will be found an exceedingly useful compendium, and the standard of excellence of the other volumes of the treatise is fully maintained. The material is systematically and conveniently arranged, and the treatise is a valuable addition to English scientific literature.

Modern Coking Practice. By J. E. CHRISTOPHER. Including the *Analysis of Materials and Products.* By T. H. BYROM. Vol. I. *Raw Material and Coke.* Vol. II. *By-Products.* Second Edition. London: Crosby Lockwood and Son. 1917. Pp. xii+110; 124. Price 7s. 6d. net.

As there have been many developments in coking practice since the issue of the first edition of this work the authors thought it advisable to revise it and bring it up to date, and are issuing the second edition in two volumes in order to expedite publication. In the first volume the processes and plant used in coke manufacture are described in full detail, great attention being paid to recent developments in coke-oven design and to the description of recent types of coke-ovens. All the statistical information has been as far as possible brought up to date, and new methods of analysis have been added. The authors' wide experience in the manufacture of coke and the analysis and sampling and valuation of fuels gives a special value to this work which provides a very satisfactory summary of the subject. The second volume deals with the by-products of the coke industry, and discusses the composition, analysis, and working up of ammoniacal liquor, the distillation of tar, benzol, and its constituents, and the general scientific control of a coke plant.

Chemistry for Beginners and Schoolboys. By C. T. KINGZETT, F.I.C., F.C.S. Second Edition. London: Baillière, Tindall, and Cox. 1918. Pp. viii+150. Price 2s. 6d. net.

THE aim of this little book is admirable, and it is satisfactory to find that it has met with such success that the first edition has very quickly been exhausted. The author has written especially for those school children and others who cannot have the advantage of working in a laboratory and thus acquiring some first-hand acquaintance with elementary scientific principles and facts. He believes that it is quite possible for a skilful teacher to give them a useful knowledge of chemistry and physics without either letting them do experiments or doing them before them, and it is certainly true that any alternative is preferable to allowing them to remain in entire ignorance of the laws of the physical universe, which is only too often the course adopted. The book contains a large amount of information in a comparatively small compass, including short outlines of light, heat, electricity, and magnetism, as well as the elements of chemistry, and a good deal of new matter has been added to the second edition. The glossary will be a great help to teachers and students, and it is much to be hoped that the use of this book will lead to the desire for wider knowledge of science in all classes of both boys and girls.

Organising and Conducting Safety Work in Mines. By HERBERT M. WILSON and JAMES R. FLEMING. Washington: Government Printing Office. 1917.

MUCH attention has lately been directed to safety measures in coal and other mines, and everywhere endeavours are being made to improve laws and regulations and to enforce them more stringently. It is fully recognised that the personal element, the senses of duty, responsibility, and caution are the most important factors to be considered in organising safety work, and the chief need is for the education and training of the miners themselves and the inspectors and bosses. This bulletin will be a great help to mining engineers in carrying out such work. It describes the measures that have been found efficacious in American mines in lowering the accident rate and generally promoting the interests of the men, laying special stress upon the need for encouraging the enthusiasm of the men for safety work, and for the most careful education and explicit instruction by means of notices, diagrams, and handbooks. It is pointed out that much good may be done by encouraging "safety suggestions" from the men and by giving lectures and holding meetings to discuss schemes and regulations.

Carbon Monoxide Poisoning in the Steel Industry. By J. A. WATKINS. Washington: Government Printing Office. 1917.

THIS bulletin aims at giving a brief account of industrial poisoning by carbon monoxide, for the use of those who do not wish or have not time to study the copious and detailed literature of the subject. The liability of workers in steel-works to such poisoning is shortly discussed, and the effects of the gas are described, especially the results of the inhalation of small quantities which are not sufficient to cause acute symptoms and may yet lead to total or partial incapacitation. Recommendations are made for preventing the pollution of the atmosphere and for reducing the liability of poisoning, and short accounts are given of the best methods of taking and analysing air samples. For full details of the most satisfactory methods of analysis reference is made to *Bulletin* No. 42 of the Bureau of Mines.

Notions Fondamentales de Chimie Organique. ("Fundamental Theories of Organic Chemistry"). By CHARLES MOUREU. Fifth Edition. Paris: Gauthier-Villars et Cie. 1917. Pp. viii+548. Price 20 francs (+ 10 per cent).

IT is possible that no other book in any language surpasses "Moureu" for its admirable summaries of the generalities of organic chemistry, which are stated with the lucidity and succinctness which are characteristic of French scientific literature. The fifth edition has been greatly enlarged with thorough revision of all parts of the text. The chapter on the atomic theory has been added to and the article on stereochemistry amplified. Special attention has been paid to the discussion of the relations between chemical composition and physical properties, and a good deal of space is devoted to the elementary study of the

mechanism of reactions. A chapter on dyes has been added to the fifth edition.

The International Movement of Fertilisers and Chemical Products Useful to Agriculture. Rome: Printing Office of the International Institute of Agriculture. September, 1917.

There has naturally been a considerable amount of difficulty in getting reliable statistics for inclusion in this bulletin, and, in fact, some information which has been given in previous years is now quite unobtainable. However, as far as possible the usual plans have been followed, though the data relating to recent periods have been collected almost entirely from private sources. The production and consumption of all the most important classes of fertilisers are tabulated, sulphur and copper sulphate being included as being of great importance in agriculture. The review is reprinted from the *Monthly Bulletin of Agricultural and Commercial Statistics* for September, 1917.

CORRESPONDENCE.

THE ENERGY THEORY OF MATTER.

To the Editor of the Chemical News.

Sir,—In connection with the article by Mr. H. Stanley Redgrove that appeared in Chemical News (vol. cvi., p. 37) entitled "A Contribution to the Energy Theory of Matter," it might be interesting to call attention to some work done by Dr. W. M. Thornton (*Phil. Mag.*, June, 1917, xxxiii., 196) which seems to have a bearing on Mr. Redgrove's work. Here Dr. Thornton has shown that the quotient obtained by dividing the M.H.C. (molecular heat of combustion) of any saturated aliphatic hydrocarbon by the number of oxygen atoms necessary for the complete combustion of one molecule of the hydrocarbon is a constant for all hydrocarbons of that class. This may be seen from the following table:—

Substance and formula.	M.H.C.	No. of O atoms needed.	Quotient, M.H.C. ÷ O atoms
Methane, CH_4	210·8	4	52·7
Ethane, C_2H_6	369·0	7	52·7
Propane, C_3H_8 . ..	527·5	10	52·7
Trimethylmethane, C_4H_{10}	685·2	13	52·7
Tetramethylmethane, C_5H_{12}	844·8	16	52·8
Di-isopropyl, C_6H_{14} .	996·6	19	52·5

With this knowledge it becomes possible to set up one more equation than Mr. Redgrove was able to, and hence to solve for one more unknown in the calculation of M.H.C. of bodies.

The general expression for a saturated aliphatic hydrocarbon is C_nH_{2n+2}. The M.H.C. of such an hydrocarbon, according to Mr. Redgrove's theory, is:—

$$M.H.C. = nC + 2(n+1)H + (n-1)L_1 \quad . \quad . \quad . \quad . \quad . \quad 1.$$

n = the number of carbon atoms in the molecule.
C = the heat due to the decomposition of one molecule of oxygen into oxygen atoms plus the heat of formation of one molecule of carbon dioxide from the carbon and oxygen atoms.
H = the heat due to the severance of a C.H link plus one-fourth of the heat due to the decomposition of one molecule of oxygen into oxygen atoms plus one-half of the heat due to the formation of liquid water from hydrogen and oxygen atoms.
L_1 = the heat due to the severance of a C.C. link.

It is now possible to set up three equations involving the three unknowns, C, H, and L_1. The first of these equations is derived from the knowledge that the M.H.C. of methane is 210·8 cals. Substituting in the general expression—

$$C + 4H = 210·8.$$

The second equation comes by substituting values for ethane in general expression, and is—

$$2C + 6H + L_1 = 369.$$

The third equation is set up from a consideration of the knowledge furnished by Dr. Thornton. Since he has shown that the quotient, obtained by dividing the M.H.C. of any saturated aliphatic hydrocarbon by the number of atoms of oxygen necessary for the complete combustion of one molecule of the hydrocarbon is a constant, it must follow that a general expression for the M.H.C. of a hydrocarbon divided by a general expression for the number of atoms of oxygen needed should also give a constant.

The general expression for the number of atoms of oxygen needed for the combustion of a molecule of a saturated hydrocarbon is obviously—

$$2n + (n+1) \text{ or } 3n + 1 \quad . \quad . \quad . \quad . \quad . \quad 2.$$

Dividing the general expression for the M.H.C. (1) by expression (2) we have—

$$\frac{nC + 2(n+1)H + (n-1)L_1}{3n+1} \text{ or } \frac{C + 2H + L_1}{3} + \frac{4H - 4L_1 - C}{3(3n+1)}.$$

It is readily seen that if the quotient is to be a constant it must not contain any expression having the variable "n." Hence, we have the third equation:—

$$\frac{4H - 4L_1 - C}{3(3n+1)} = 0 \text{ or } 4H - 4L_1 - C = 0.$$

Collecting the three equations—

$$C + 4H = 210·8, \quad 2C + 6H + L_1 = 369,$$
$$4H - 4L_1 - C = 0.$$

Solving—

$$C = 210·8, \quad H = 0, \quad L_1 = 52·7.$$

The value of the heat due to the severance of a double bond can now be easily calculated by substituting experimental values into the general expression for the M.H.C. of an aliphatic hydrocarbon containing one double bond:—

$$M.H.C. = nC + 2nH + (n-2)L_1 + L_2.$$

The average value for L_2 is found to be -89.

In a similar manner the heat due to the severance of a triple bond is found to be about -113.

These results are quite different from those calculated by Mr. Redgrove upon the assumption that the heats due to the carbon and hydrogen are nil, for the actual value of carbon is found to be 210·8 cals. We, too, are unable to calculate the actual value of the hydrogen, but the sum of the heat due to the hydrogen and the heat due to the severance of the carbon-hydrogen link is found to be zero. If the heat due to the severance of this link is negative, as is the case with the carbon-carbon link, then the hydrogen would also have a positive value.

This consideration, then, seems to disprove the statement made by Mr. Redgrove to the effect that "properties of bodies can be regarded as primarily functions of the

number and sort of valency-bonds within their molecules," at least in so far as M.H.C. of bodies are concerned. However, it does not disprove the idea that the energy changes in a reaction depend upon the valency changes, for the heat due to the combustion of the carbon is made up of the heat due to the severance of the links in the oxygen molecule and the heat due to the formation of carbon-oxygen links in the carbon dioxide produced. In fact, it seems to strengthen this view. It remains for more relationships to be discovered before the exact value of each bond may be calculated.—I am, &c.,

ELMER B. VLIET.

709, South Second Street, Champaign, Illinois, U.S.A., December 5, 1917.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

NOTE.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdmadoaires des Séances de l'Académie des Sciences. Vol. clxv., No. 24, December 10, 1917; No. 25, December 17, 1917.

These numbers contain no chemical matter.

No. 26, December 24, 1917.

Separation of the Secondary Amines obtained by the Catalytic Hydrogenation of Aniline.—Gustave Fouque.—The catalytic hydrogenation of aniline yields cyclohexylamine, dicyclohexylamine, cyclohexylaniline, diphenylamine, and some secondary products such as benzene, cyclohexane, and tar. It is not possible to separate the three secondary amines by simple fractional distillation, but they may be isolated by a method based upon the following facts:— (i.). The hydrate of dicyclohexylamine is a strong base, which gives a solid carbonate, soluble in water, and three soluble sulphates, non-hydrolysable, the neutral sulphate, the sesquisulphate, and the bisulphate. (ii.). Cyclohexylaniline does not give a carbonate. It gives a neutral sulphate, a sesquisulphate, and a bisulphate, which are all hydrolysable, but soluble in water acidulated by sulphuric acid. (iii.). Aniline does not give a carbonate. (iv.). The sulphate of diphenylamine has not been isolated.

Bulletin de la Société Chimique de France. Vol. xxi.-xxii., No. 11, 1917.

Action of Hydrogen Peroxide on Neutral Salts of Lead.—V. Zotier.—Hydrogen peroxide reacts on lead salts with formation of lead peroxide, which decomposes a part of the hydrogen peroxide used. With neutral salts there is no residual PbO_2, and with basic salts there is only a small proportion of PbO_2. With alkaline solutions, however, there is a considerable residue of PbO_2, at any rate with concentrated plumbic solutions.

MISCELLANEOUS.

Chemical Society.—The Annual General meeting will be held on Thursday, March 21, 1918, at 4.30 p.m., when the President will deliver his Address. There will be an Informal Meeting the same evening after the conclusion of the formal business of the Ordinary Scientific Meeting to be held at 8 p.m. The Council will gladly welcome assistance from any Fellows who are able to increase the scientific interest of the Informal Meetings by showing experiments or apparatus, and all offers of such assistance should be made to the Assistant Secretary not later than the Monday previous to the meeting.

Association of Metallurgists and Metallurgical Chemists.—This Association has recently been formed in Sheffield, its aim being the furtherance of the efficient application of scientific knowledge to industry. Full members of the Association must be men holding suitable academic qualifications, or such as can show themselves to have had considerable experience and to possess adequate theoretical knowledge. Men of lower qualifications who are holding responsible posts may become Associates or Honorary Members. Members of works staffs will be welcomed at the meetings, and it is hoped that the Association will help to bring together the scientific worker and the man in charge of operations at the works. The new Association will have the hearty good wishes of all who are interested in the spread of scientific knowledge in England and in the improvement of the relations between the scientific worker and the practical man. The President of the Association is Mr. W. H. Hatfield, D.Met., and the Hon. Secretary, Mr. G. R. Bolsover, 31, Rossington Road, Brocco Bank, Sheffield, who will provide any further information.

Federation of British Industries.—The report which has been drawn up by the Education Committee of the Federation of British Industries will well repay careful study by all who have at heart the welfare of the Empire. The report has received the support of over 2000 firms of all sizes and engaged in all industries throughout the country, and it may thus be regarded as an authoritative statement of opinions upon the proposals of the President of the Board of Education regarding the reform of education. It is agreed that the leaving age should be raised to fourteen, but it is not thought advisable that part-time education for all up to eighteen should be compulsory. It is suggested that at twelve years of age each child in the elementary schools should be placed in one of two classes:—(*a*) The more promising children, who should either be drafted straight into a secondary school or into a junior technical school. (*b*) The less promising children, who should remain in the primary school until the age of fourteen, meanwhile receiving a general and practical training, which might be partly vocational. Under this scheme all the more able children would receive a full-time course of secondary education. The report discusses the need for improving the teaching staff of elementary schools, and advises that a general university training should be regarded as an absolute necessity for all who teach above the infant standards, and it is recognised that it is preferable that all intending teachers should have the opportunity of mixing with fellow students who are destined for other careers. Hence it is suggested that some of the existing training colleges had better be abolished. The linking up of the educational machinery with industry is also briefly discussed in the report, as well as the question of the increased expenditure which would be bound to be one outcome of the adoption of the scheme.

MEETINGS FOR THE WEEK

MONDAY, 11th.—Biochemical Society, 5.30. (In the Institute of Physiology, University College, London). Annual General Meeting.
TUESDAY, 12th.—Royal Institution, 3. "The Stifling of Children's Health," by Dr. Leonard Hill.
WEDNESDAY, 13th.—Royal Society of Arts, 4.30. "Ypres and other Flemish Cities Before and Since the War," by Paul Lambotte.
THURSDAY, 14th.—Royal Institution, 3. "War Music—Past and Present," by Sir Alexander Mackenzie.
— Royal Society of Arts, 4.30. "English Commerce with India, 1608-1658," by Wm. Foster.
FRIDAY, 15th.—Royal Institution, 5.30. "The Romantic Movement," by The Rt. Rev. W. Boyd-Carpenter, K.C.V.O.
SATURDAY, 16th.—Royal Institution, 3. "Problems in Atomic Structure," by Sir J. J. Thomson.

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THE CHEMICAL NEWS

Vol. CXVII., No. 3042.

RELATION BETWEEN THE AFFINITY VALUES OF THE ALIPHATIC ACIDS OF THE MONO- AND DI-BASIC SERIES.

By GERVAISE LE BAS.

The affinity values of these acids have been compared with the following results. The data are given in Table I.

Table I.—*Table of Values.*

	$k \times 10^4$.
Monobasic fatty acids—	
HCO_2H	0·021
$CH_3.CO_2H$	0·00180
$C_2H_5.CO_2H$	0·00134
$C_3H_7.CO_2H$	0·00149
$C_4H_9\ CO_2H$	0·00161
$C_5H_{11}.CO_2H$	0·0016
$C_6H_{13}.CO_2H$	0·0017
Dibasic fatty acids—	
$(COOH)_2$	—
$CH_2(COOH)_2$	0·1580
$C_2H_4(CO_2H)_2$	0·00660
$C_3H_6(CO_2H)_2$	0·00473
$C_4H_8(CO_2H)_2$	0·00376
$C_5H_{10}(CO_2H)_2$	0·00296
$C_6H_{12}(CO_2H)_2$	0·00273

If the second series of numbers be studied it will be found that they constitute a nearly arithmetical series; that is, starting from succinic acid (Table II.)

Table II.

	$n(K \times 10^{-4})$.
$C_2H_4(COOH)_2$	2 × 0·00660 = 0·01320
$C_3H_6(COOH)_2$	3 × 0·00473 = 0·01419
$C_4H_8(COOH)_2$	4 × 0·00376 = 0·01504
$C_5H_{10}(COOH)_2$	5 × 0·00296 = 0·01480
$C_6H_{12}(COOH)_2$	6 × 0·00273 = 0·01638

There is a small progressive increase in the numbers, but they are very nearly the same.

It may be useful to compare the members of the dicarboxylic with those of the monocarboxylic acid series.

If one set of numbers be divided by the other, the numbers given in Table III. are obtained.

Table III.

Oxalic / Formic	= 0·021	=
Malonic / Acetic	= 0·1580 / 0·0018	= 88·00
Succinic / Propionic	= 0·00660 / 0·00130	= 5·08
Glutaric / Butyric	= 0·00473 / 0·00150	= 3·15
Adipic / Valeric	= 0·00376 / 0·00160	= 2·35
Suberic / Caproic	= 0·00296 / 0·00160	= 1·85
Sebasic / Caprylic	= 0·00276 / 0·00170	= 1·62

If these numbers be plotted on a diagram against successive integers 1, 2, 3, 4, 5 . . it will be found that the points lie upon a curve resembling a rectangular hyperbola.

It is now necessary to find out whether the curve conforms to the condition—

$$xy = \text{const.}$$

or not.

This is done by finding the origin.

$$5·08\,x = A \text{ (const.)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

$$3·15\,(x+1) = A \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

It is found that—

$$x = 1·632.$$

The origin is thus 0·632 behind the ordinate marked 0.

The constant is found to have the following value:—

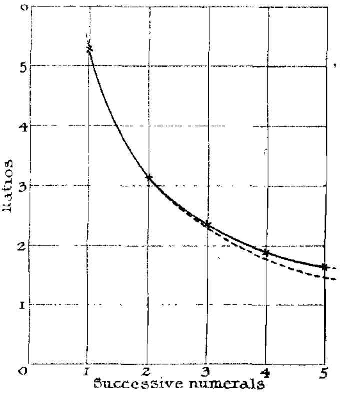
$$A = 5·08 \times 1·632 = 8·29.$$

Table IV. shows how closely the curve conforms to the conditions stated; that is, to the rectangular hyperbola.

Table IV.

	Ratio (r).	y.	xy = A.
Succinic / Propionic ..	5·08	1·632 (2)	8·29
Glutaric / Butyric ..	3·15	2·632 (3)	8·29
Adipic / Valeric ..	2·35	3·632 (4)	8·53
Suberic / Caproic ..	1·85	4·632 (5)	8·57
Sebasic / Caprylic ..	1·62	5·632 (6)	9·12

The dotted line shows the continuation of the curve on



the assumption that it is a rectangular hyperbola, and consequently the departure from these conditions.

The first two ratios—

Oxalic / Formic   Malonic / Acetic

do not lie upon this curve, although they are very large, as would be the case if they did conform to the conditions.

The free energy due to the carboxylic group is not constant in the first series, but diminishes rapidly as the hydrocarbon chain increases in length.

When there are two such groups in the same molecule the ratio between the affinity values practically varies inversely as the number of carbon atoms between the groups, but in HOOC.COOH *and* $HOOC.CH_2.COOH$ *the ratio increases according to some higher power.*

The affinity values are calculated from the total condition, but as has been shown so frequently the total or grm. molecular condition is a guide to the molecular condition. One might thus suppose that in the formula—

$$R-COOH \rightarrow R-COO(-) + H(+)$$

the free energy depends upon the length of R.

Also in—

$$H(+) + (-)OOC-(CH_2)_n-COO(-) + H(+)$$

the free energy is due partly to the nature of these groups, and to their interaction, and will be related to that in the first series in such a way that the ratio diminishes inversely as the number of methylene groups increase.

(*a*) It is fairly certain that the hydrocarbon elements, methylene (CH_2), are able to fix or neutralise some of the *residual affinity*.

(*b*) The two carboxylic acid groups are able to excite one another to activity, or increase the amount of the residual affinity in a manner *which varies inversely as the number of interposed methylene groups.*

These two opposite actions have to be considered in discussing the affinity constants. So does the optical anomaly (Table V.).

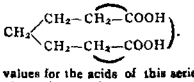
TABLE V.

	R_α	$\Sigma_n R_\alpha$	Δ.
Formic acid, CH_2O_2	8·52	8·30	+0·20
Acetic acid, CH_3COOH	12·98	12·90	+0·03
Propionic acid, $C_2H_5.COOH$ ..	17·42	17·50	−0·05
Butyric acid, $C_3H_7.COOH$ ..	22·05	22·10	−0·05
Succinic acid, $C_2H_4(COOH)_2$ ..	23·97	23·74	+0·23

The differences given in Table V. are evidently *not* commensurate with the variations in the value of K, but they both undoubtedly show the saturating power of the hydrocarbon residues.

In the dicarboxylic acid series the first effect to be noted is the mutual action of the two carboxylic groups; that is, the one increases the tendency of the other to activity or to possess residual affinity. This effect is diminished by the interposition of methylene groups, because the individual carboxylic groups become less active for the reason stated. Not only is the variation from compound to compound nearly constant, but the values of K themselves are multiples of the simple integers 2, 3, 4, 5 . . . which represent the number of carbon atoms interposed between the carboxylic groups. It follows that the interaction of one group on the other varies inversely as the number of interposed carbon atoms as against the action through the hydrocarbon chain. If the monocarboxylic and dicarboxylic acids be compared it will be seen that in the latter case the diminution of K to its constant value does not take place till the compound $C_6H_{12}(COOH)_2$ is reached. The mean of the last five values in the first series is 0·00155, and twice this value is 0·0031. Interaction in the first four members of the dicarboxylic acid series is evident. The two carboxylic groups, then, under these *conditions act independently.*

A suggested formula for these dicarboxylic acids which takes these facts into account is thus—



Since the values for the acids of this series are in the denominator, the ratios are in consequence augmented. For this reason probably the first two ratios are out of harmony with the others.

THE OILS IN CHERRY PITS.

By HAROLD L. MAXWELL.

It has been the subject of much speculation as to how the Germans have been supplied with fats for food and to furnish the glycerin from which the important explosives, *dynamite and nitroglycerin, are made.* They have been charged with having extracted fat from their enemy dead to be used in making the explosives.

An important source of oil in Germany are doubtless cherry pits, and it is quite likely that German thrift and efficiency would not be slow to utilise that material. There is scarcely any other country on the globe where the cherries have reached so high a degree of perfection as in Germany. Cherry trees are everywhere, and the cherries are unusually large and constitute an important article of food during the early summer. We thought it might not be devoid of interest to investigate the oil content of the cherry pits.

We secured a quantity of the dried seeds of the common cherry *Prunis erratus* and by cracking we obtained 50 grms. of the kernels. These we crushed in a mortar, removed to a cloth sack, and placed in flask A of the extraction apparatus illustrated below. The oil which adhered to the mortar, as a result of the crushing, was washed with ether and added to the contents of the flask.

The material to be extracted is placed in flask A. Both flasks are then half filled with the solvent, ether, alcohol, or water as the case may be. The syphon is then filled with the solution and both flasks heated on a water-bath. The ether vapour created in flask B will force its way *through the short syphon into flask A, where it is condensed* by the condenser above. The vapour from flask A will condense in the same way and return to the same flask. This operation lowers the level of the liquid in flask B and raises the level in flask A, thus starting the syphon which carries the oil laden ether from flask A to B. Here the ether vaporises, leaving its burden of oil in flask B, and returning in the form of vapour to flask A to be condensed and begin anew its cycle of extracting, transporting, and depositing another portion of oil.

We have used this apparatus with various solvents and on different substances. In each case we have found it to be accurate and very economical in both time and solvent.

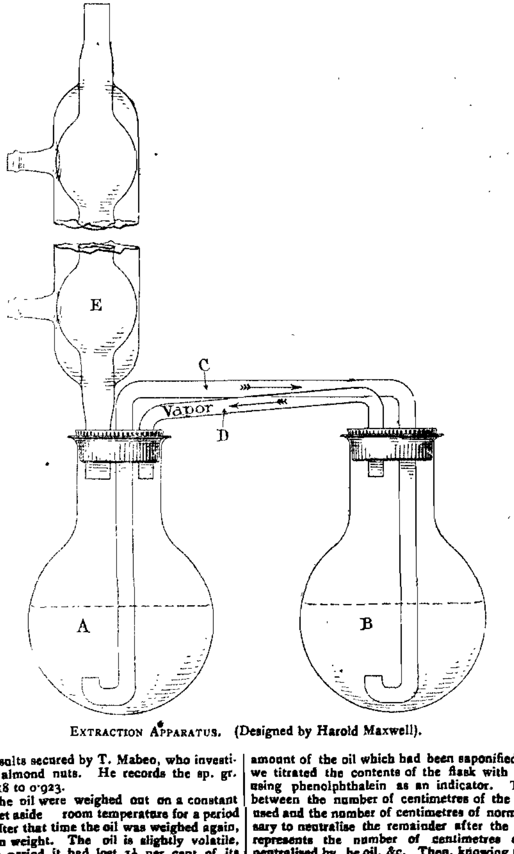
After the extraction had continued for fifty-six hours the oil laden ether was taken from flask B and to it was added the ether from flask A, in order to insure against the loss of even the smallest quantity of the oils. The ether and oil mixture was distilled at the lowest possible temperature. The boiling point of the ether being 34·9°, the mixture began to distil at a slightly higher temperature, about 36° C. By fractional distillation the oil was separated from the solvent. To insure the evaporation of all the ether the oil was placed in an open beaker and heated on a water-bath at 76° C. for three hours. After this treatment even the faintest trace of ether could not be detected.

The yield was unusually large. From the 50 grms. we secured 18·8 grms. of the oils, or a yield of 37·6 per cent. The oils have the characteristic odour of almonds. The taste is pleasant, resembling nuts. They are light amber in colour and have about the consistency of warm castor oil.

The German Pharmacopœia states that pure almond oil should remain clear at −10° C. This specimen became opaque, showing that we had a mixture of oils and not one individual. At low temperatures the oils showed marked changes. The first change in colour began at −5° C., when white globules separated out and settled to the bottom. This indicated that one of the oils solidified at that temperature. We kept that temperature constant until all the oil which had a tendency to solidify had separated out. We set this oil aside for further study, which we record later. The amber oil, which constituted about 90 per cent of the whole oil content, was drawn off

with a pipette and subjected to lower temperatures. At −18° C. there was no sign of solidification, but at −19° C. the oil became viscous, while at −20° C. it began to appear solid.

The specific gravity of the oil was next determined by weighing out several portions of 1 cc. each on a watch-glass of constant weight, and computing the weight per centimetre of the oil. We found the sp. gr. to be 0·922, 0·925, and 0·924 in three respective cases. This is consistent with the results secured by T. Mabeo, who investigated the oil in almond nuts. He records the sp. gr. of that oil as 0·918 to 0·923.



Extraction Apparatus. (Designed by Harold Maxwell).

Two grms. of the oil were weighed out on a constant watch-glass and set aside room temperature for a period of forty hours. After that time the oil was weighed again, noting the loss in weight. The oil is slightly volatile, since during that period it had lost 1½ per cent of its original weight.

In determining the saponification equivalent of the oil under examination we first prepared a normal solution of KOH in absolute alcohol. This was done by dissolving 56 grms. of KOH in 800 cc. of the solvent and then diluting to a litre. We weighed 4·317 grms. of the oil into an eight ounce flask and added to it exactly 30 cc. of the alcoholic solution of KOH. The flask was connected with an inverted condenser and the contents kept at a boiling temperature for thirteen hours. We cooled the flask and added 200 cc. of water. Then to determine the amount of the oil which had been saponified by the KOH we titrated the contents of the flask with normal HCl, using phenolphthalein as an indicator. The difference between the number of centimetres of the normal KOH used and the number of centimetres of normal HCl necessary to neutralise the remainder after the saponification represents the number of centimetres of the KOH neutralised by he oil, &c. Then, knowing the strength of the solution and the nature of the oil, we can determine the percentage of the saponifiable oil. The saponification

equivalent is the object of this experiment, and to compute that we divide the weight of the oil in mgrms. by the number of cubic centimetres of KOH solution neutralised by the oil. In this case we found it to be 276·8. E. Valenta investigated the oil from almond nuts and found the saponification equivalent to be 285, and that in some cases it ranged as high as 296, depending on the purity of the specimen. Thoerner, in a study of the mixed fatty acids of almond oil, found the equivalent as low as 204.

It has been observed by various investigators that many fatty oils produce highly coloured products when treated with sulphuric acid. After this suggestion we set out with this method to determine the nature of the two oils.

Taking first the light amber oil, which constituted the main portion of the mixture of oils, we added two drops of concentrated sulphuric acid to twenty drops of the oil. At first there was no colour, but on stirring with a glass rod the oil and acid mixture became brown and in a few minutes it began to solidify. This also is characteristic of almond oil.

Some of the smaller portion of the oil which had separated out on being cooled in the first part of the investigation was given the same treatment with a few drops of sulphuric acid. When the mixture was stirred the colour turned from a yellow to a reddish brown with a purple cast. This indicated the presence of Arachis oil, the principle oil in peanuts. There was only a small amount of this oil present in the specimen. This was not sufficient for a complete and thorough analysis.

There are three sources from which almond oil may be obtained—Almond nuts, peach kernels, and apricot kernels. Then since the cherry seed belongs to no one of these three classes our next question might well be—Which one of the three does it most resemble?

Samples of almond oil from each of the three sources vary in specific gravity, bromine absorption, and colour tests. In the first two instances the variation is so slight that, allowing for even the smallest error, the line of difference is indistinct. It is then the colour tests that mark the dividing line between the almond, peach, and apricot oils. The zinc chloride test is the one employed as follows: Add five drops of the strong zinc chloride solution to ten drops of the oil. If there is no change in colour after stirring the oil is identical with that from the almond nut. If the colour changes to purple or brownish purple the oil is from the peach kernel. While if the mixture changes to a muddy or a dirty brown the oil is the same as that from the apricot kernel. In the sample of oil being examined there was no change of colour, showing that the oil in this analysis is the same as from the almond nuts.

The taste and odour of cyanogen in the freshly cracked cherry pits is evidence of the presence of nitrogen. By the use of the Gunning method we determined the percentage of nitrogen in the kernels and found no less than 5·6 per cent. It is to be expected that the ether extraction would remove a part of the cyanogen with the oil. We took a grm. of the dried residue after all the oil had been extracted and made another nitrogen determination. In this we found 4·2 per cent of nitrogen, showing that the main portion of the nitrogen was neither extracted by the ether or expelled by the long heating of the water-bath.

The residue from the crushed cherry pits was taken from the flask and dried in the air for ten hours. Then it was heated on the water-bath at 100° C. for fifteen hours to expel the remaining ether and the moisture. The dry residue was weighed and the loss in weight found to be 20·9 grms. The oils extracted weighed 18·8 grms., leaving a difference of 2·1 grms. This is no doubt the weight of the water expelled from residue when it was heated to drive off the remaining ether.

When cherry seeds or oil-bearing nuts are ground up with cold water the amygdalin breaks up in an emulsion. The oil is partly broken down in the process and glucose sugars constitute one of the resulting products. To confirm the presence of the glucose sugars in the water extraction we treated a quantity of the dried seeds with water for twenty-four hours. We titrated a fractional part with standard Fehling solution and found 19·8 per cent of sugars present: Reaction—

$$C_{20}H_{27}NO_{11} + 2H_2O = C_7H_6O + HCN + 2C_6H_{12}O_6.$$

The cherry oil, which has been found to be essentially the same as the almond oil, consists of olein with a small quantity of stearin and palmitin. Olein is the chief constituent of the fatty oils, and may be made by heating glycerin with an excess of oleic acid at 204° C. Its formula is $C_{57}H_{104}O_6$.

It is not to be expected that the Central Powers, with their urgent need of oil for food and explosives, have overlooked such a productive source of glycerin as we have found in the cherry pits. The production of the countless tons of explosives necessary to carry on a war has called into service every resource of the nation. This is an item then not to be under-estimated, for already the cherry-seed oil has contributed its bit to the great world war.

Cornell College, Mount Vernon, Iowa,
January 25, 1918.

ON THE PREPARATION AND HYDROLYSIS OF ESTERS DERIVED FROM THE SUBSTITUTED ALIPHATIC ALCOHOLS.*

By W. A. DRUSHEL and G. R. BANCROFT.

(Concluded from p. 112).

Hydrolysis of Esters.

Esters Derived from Alpha Substituted Ethyl Alcohols.—The following esters of this class were studied:—

α-chlor-ethyl acetate, $CH_3.CHCl.O.CO.CH_3$.
α-ethoxy-ethyl acetate, $CH_3.CH(OC_2H_5).O.CO.CH_3$.
α-chlor-ethyl propionate, $CH_3.CHCl.O.CO.CH_2.CH_3$.

These esters are found to be unstable compounds, which are decomposed immediately upon dissolving in decinormal hydrochloric acid. This was shown by dissolving 2·5 cc. of the α-chlor-ethyl acetate in 250 cc. of the standard decinormal hydrochloric acid. On titrating 25 cc. of this reaction mixture with decinormal sodium hydroxide, the initial titration required considerably over 45 cc., and the titration made after allowing the reaction mixture to remain in the thermostat for ten days showed an increase of only 1 to 2 cc. This increase was accounted for by the more complete splitting out of halogen, which was shown by titrating with silver nitrate.

In the case of the α-chlor-ethyl acetate the hydrolysis products were acetaldehyde, acetic acid, and hydrochloric acid, while the α-chlor-ethyl propionate gave acetaldehyde, propionic acid, and hydrochloric acid. The α-ethoxy-ethyl acetate gave a similar result yielding acetaldehyde, ethyl alcohol, and acetic acid. The presence of the aldehyde was shown in each case by treating a portion of Schiff's reagent with a few drops of the solution of the hydrolysed ester, which at once imparted a deep reddish violet colour to the solution.

In alkaline solution the reaction was similar to that described above, and the presence of the aldehyde was shown by warming the solution of hydrolysis products on the steam bath, when there was formed the characteristic aldehyde resin of acetaldehyde.

Esters Derived from Beta Substituted Ethyl Alcohols.—The following esters of this class were studied:—

β-hydroxy-ethyl acetate, $CH_2(OH)CH_2.O.CO.CH_3$.
β-methoxy-ethyl acetate, $CH_2(OCH_3).CH_2.O.CO.CH_3$.
β-ethoxy-ethyl acetate, $CH_2(OC_2H_5).CH_2.O.CO.CH_3$.
β-chlor-ethyl acetate, $CH_2Cl.CH_2.O.CO.CH_3$.
β-brom-ethyl acetate, $CH_2Br.CH_2.O.CO.CH_3$.

These esters were hydrolysed in decinormal hydrochloric

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* From the *American Journal of Science*, xliv., p. 371.

acid at 25°, 35°, and 45°, and measurements made from which the velocity constants were calculated. The hydrochloric acid used as a catalysing agent was standardised by precipitation with silver nitrate. The titrations were made with decinormal sodium hydroxide, free from carbon dioxide, using phenolphthalein as an indicator.

The hydroxy-, methoxy-, and ethoxy-ethyl acetates were found to be very soluble in water. The introduction of *halogen in the β-position of the ethyl radical of the alcohol* gives to the derived ester a much greater insolubility. Only 8 cc. of the β-brom-ethyl *acetate* could be dissolved in a litre of water. The β-chlor-ethyl acetate was found to be slightly more soluble.

In the case of the hydroxy-, methoxy-, and ethoxy-ethyl acetates 2·5 cc. of each ester were dissolved in 250 cc. decinormal hydrochloric acid, previously warmed in the thermostat to the required temperature. As soon as the ester was completely dissolved a 25 cc. portion of the reaction mixture was withdrawn by means of a pipette, and run into about 100 cc. of cold distilled water in a 300 cc. flask. The pipette was allowed to drain thirty seconds and the time was then recorded, and the solution titrated at once with decinormal sodium hydroxide. Subsequent titrations were made at suitable time intervals, and the final measurements were taken when a sufficient time had elapsed to insure that the hydrolytic action was complete. To insure uniformity in experimental conditions a sample of ethyl acetate was hydrolysed at the same time as the esters of this group, and the hydrolysis of each ester was made in duplicate.

On account of the greater insolubility of the β-halogen substituted esters only 2 cc. of each ester were dissolved in 250 cc. of *decinormal* hydrochloric acid. Measurements of the velocity of the hydrolysis of these esters were made as just described. In order to ascertain if any halogen was liberated in the form of free halogen acids derived from the esters, or the halogen substituted alcohols resulting from the hydrolysis of the esters, titrations were made with decinormal silver nitrate at the time when the equilibrium was reached in the titration of the acid with decinormal sodium hydroxide.

At 25° and 35° there was no splitting out of halogen in the case of the β-chlor-ethyl acetate, and none from the β-brom-ester at 25°. At 35 and 45°, however, the β-brom-ethyl acetate was found to decompose slightly in this way, and at 45° a slight decomposition was indicated in the case of the β-chlor-ethyl acetate, which was so small as to be negligible. The necessary correction for the formation of halogen acid was applied to the titrations made at 35 and 45° in the hydrolysis of the β-brom-ethyl acetate, where as much as 4 per cent to 4·5 per cent of the halogen was found to be set free as halogen acid.

From the titrations made as described above the velocity constants recorded in Table I. were calculated by using the titration formula for monomolecular reactions:

$$K = \frac{2·3}{t}\left[\log\,(T_{\infty} - T_0) - \log\,(T_{\infty} - T_n)\right],$$

where T_0 is the initial titration, T_{∞} the final titration, and T_n an intermediate titration all expressed in cubic centimetres of decinormal sodium hydroxide, and t represents the time interval in minutes between the initial titration T_0 and that represented by T_n.

On referring to Table II. it is seen that the substitution of chlorine, of hydroxyl, and of ethoxyl groups in the β-position produces practically the same retardation of the rate of hydrolysis in each case. The substitution of bromine in the β-position produces a retardation of the hydrolysis which is considerably less than that produced by the chlorine substitution. The ethoxyl group produces a slightly greater retardation than the methoxyl group.

The temperature coefficients are found to vary from 2·2 to 2·5 for an increase of 10°. The substitution of bromine in the β-position has a lowering effect upon the temperature coefficient. In the case of other esters of this series the coefficients were found to be practically constant, having the values of 2·5 for the range from 25—35° and 2·3 to 2·4 for the increase from 35—45°.

Summary.

1. The β-hydroxy-ethyl acetate may be prepared by refluxing equimolecular quantities of ethylene glycol and glacial acetic acid for eight hours over twice the theoretical quantity of anhydrous copper sulphate.

2. *By* heating equimolecular quantities of ethylene dibromide and freshly fused potassium acetate on a water bath *for eighteen hours, the product obtained is glycol* diacetate and not the β-hydroxy-ethyl acetate.

TABLE I.

Hydrolysis at 23° in Decinormal Hydrochloric Acid.

Ester.		β hydroxy-ethyl acetate.	β-methoxy-ethyl acetate.	β-ethoxy-ethyl acetate.	β-chlor-ethyl acetate	β brom-ethyl acetate.
Time ..		2830	—	3300	2943	2835
K × 105		46·2	—	46·8	47 4	53·3
		47·4	—	47·1	46·5	54·2
		47·1	—	46·6	46 3	54·0
		46 9	—	46·2	46 0	55·4
		47·3	—	46·1	46·0	55·8
		47·2	—	46·5	47·4	56·0
		47·6	—	45·5	46·1	56·9
Averages		47·1	—	46·4	46·5	55 I
Averages (duplicate)		47·2	—	46 6	47·2	56 5

Hydrolysis at 35° in Decinormal Hydrochloric Acid.

Time ..	660	840	870	660	660
K × 105	(111·8)	122 8	117 8	115·5	—
	115 6	121 2	117·3	117·5	(109·3)
	117 8	119 6	117·0	118 4	124·2
	117·6	122·3	118 2	118·2	132·2
	117·9	122·6	117·2	117·4	135 5
	117·2	123·4	117·5	117·6	139·7
	118 6	123·7	118 5	118 6	140·7
Averages	117·4	122·2	117 6	117·6	134·5
Averages (duplicate)	117·2	122·8	117 7	117·6	134·9

Hydrolysis at 45° in Decinormal Hydrochloric Acid.

Time ..	210	212	213	210	210
K × 105	(252)	(259)	(277)	(252)	—
	280	281	279	271	(226)
	278	281	279	272	288
	278	280	278	273	297
	278	283	279	278	298
	279	283	280	277	306
	280	282	280	278	300
Averages	279	282	279	275	298
Averages (duplicate)	279	281	280	275	297

TABLE II.—SUMMARY.

Temperature ...	K + 10^5 25°	K + 10^5 35°	K + 10^5 45°	Temp. coeff. 25—35°	Temp. coeff. 35—45°
Ethyl acetate	64 7 64·8	162·1 161·9	379·0 376·0	2·5	2·3
β-hydroxy-ethyl acetate	47 1 47·2	117·4 117·2	279·0 279·0	2·5	2·4
β-methoxy-ethyl acetate	— —	122·2 122·8	282·0 281·0	—	2·3
β-ethoxy-ethyl acetate	46·6 46 4	117·6 117 7	279·0 280·0	2·5	2·4
β-chlor-ethyl acetate	55·1 56·5	134·5 134·8	298·0 298·0	2·4	2·2

3. β-ethoxy-ethyl alcohol is formed by digesting equimolecular quantities of β-brom-ethyl acetate and sodium ethylate for half an hour in alcoholic solution.

4. The substitution of halogen or an alkoxyl group in the α-position of the alkyl radical of an ester accelerates the decomposition of the ester to such an extent that the reaction velocity is not measurable. In the case of all three esters of this type that were hydrolysed acetaldehyde formed one of the hydrolysis products.

5. The substitution of hydroxyl, alkoxyl, or halogen in the β-position of the alkyl radical produces a considerable retardation on the rate of hydrolysis. In the case of the esters derived from the β substituted ethyl alcohols it was found that the hydroxyl and ethoxyl groups and chlorine produce practically the same degree of retardation.

6. The ethoxyl group produces a slightly greater retardation than the methoxyl group.

7. The introduction of halogen in the β-position of the alkyl radical produces a retardation of the rate of hydrolysis. In the case of the β-brom-ethyl acetate this retardation is less than in the case of the β-chlor-ethyl acetate.

8. The temperature coefficients in the case of the esters derived from the β-substituted alcohols are found to vary from 2·2 to 2·5 for an increase of 10°. The substitution of bromine in the β-position has a lowering effect upon the temperature coefficient.

STRONTIUM:

Its Occurrence, Industrial Application, and the Manufacture of its Salts.*

By RICHARD K. MEADE,
Consulting Chemical Engineer.

Strontium was discovered as an independent element almost simultaneously, in 1792, by Hope, an English, and Klaproth, a German chemist. Davy first obtained the impure metal by an electrolytic method similar to that which he employed in preparing metallic barium, but the pure metal was first made by Bunsen and Matthiessen in 1855.

The name Strontium is derived from the mineral strontianite, which is a carbonate of the metal. This mineral was first noticed in the lead mines of Strontian, a town in Argyleshire in Scotland, hence its name.

Metallic strontium may be prepared by the same methods employed to obtain metallic barium; the most common being the electrolysis of a molten bath of strontium chloride in the presence of ammonium chloride. It may also be prepared by plunging sodium amalgam into a hot saturated solution of strontium chloride, whereby strontium amalgam is formed; this latter is then decomposed by distilling off the mercury in a current of hydrogen, the strontium metal remaining in the retort.

Strontium is a yellowish metal of specific gravity 2·5. It decomposes water at ordinary temperatures just as do potassium and sodium, oxidises rapidly in the air, and burns with a reddish flame.

Occurrence.

According to Clark, strontium is much less abundant than barium but more so than nickel or lithium for example. It forms about 2/100 of one per cent of the earth's crust. It is found in sea water, in minute traces it is true, but nevertheless it may be detected in this by the ordinary analytical methods, and also in many igneous rocks.

The two principal minerals in which strontium occurs are *celestite*, the sulphate of the metal, and *strontianite*, the carbonate. Of these two, the sulphate only is found in bodies of sufficient size to constitute a source of supply for the metal and its salts. Strontium also occurs in appreciable quantities in minerals which are mixtures of this metal with barium and calcium, notably the barite from Kentucky, but these latter ores can hardly be considered as a source of strontium owing to the difficulty of separating it from the other metals.

Celestite, or native strontium sulphate, should contain when pure 56 per cent strontia, SrO, and 44 per cent sulphur trioxide, SO_3. It is rarely found pure, however, the principal impurities being silica and the oxides of iron, aluminium, calcium, barium, and sodium. To be commercially acceptable it should contain at least 50 per cent strontia, corresponding to about 90 per cent strontium sulphate.

Celestite resembles barite in appearance, and like the later mineral is heavy and soft. It has a specific gravity of 4·0, when pure, or a little less than that of barite (4·3 to 4·6). It has about the same fusibility as the latter mineral (3 on the Mohr's scale), being easily fused in the blowpipe flame, and about the same hardness (2 to 3), being easily scratched by a knife. In colour the mineral is white with a vitreous pearly lustre, and the cleavage is nearly perfect in three directions at about right angles to one another. The cleavage faces usually show a translucent bluish cast, but sometimes a reddish cast.

Strontianite, the native carbonate, is a relatively rare mineral, and hence is of academic rather than practical importance. It would be an excellent source of strontium salts, if obtainable in quantity, however, as it is soluble in most dilute acids, and hence could be easily converted into strontium salts. When pure it contains 70 per cent strontia and 30 per cent carbon dioxide. The mineral has a specific gravity of 3·7 and a hardness of 3. It is brittle and difficultly fusible. Its colour varies from white to pale green or to yellow.

Brewsterite is a hydrous silicate of strontium, barium, calcium, and aluminium containing usually less than 10 per cent strontium. Strontiano-calcite is a strontium bearing calcite and baryto-celestine a strontium bearing barite. All are quite rare and of no commercial importance.

Detection of Strontium.

The strontium minerals are recognised by the fact that if pulverised and heated with a little hydrochloric acid and a platinum wire is moistened with this mixture and held in a non-luminous flame the latter is coloured crimson. The flame coloration produced by strontium is much more brilliant than that produced by calcium, which is only a dull red, while strontium is a bright crimson. Strontianite is quite soluble in hydrochloric acid, but celestite is but slightly so. A saturated solution of calcium sulphate added to the solution of strontianite after the latter has been evaporated to a syrup will produce a white precipitate. Celestite may be told from strontianite by the fact that the latter dissolves in hydrochloric acid with considerable effervescence, while the former does not. Celestite, if powdered, mixed with sodium carbonate and ground charcoal and the mixture heated on a piece of charcoal, cooled, moistened, and placed on a silver coin, stains the latter black. Strontianite does not. Either mineral after heating strongly will, if moistened and placed on red litmus paper, turn the latter blue. Both strontianite and celestite are fusible, the latter more so than the former.

In the analysis of strontium ores the finely powdered samples should be fused with about ten times its weight of sodium carbonate and the fused mass extracted with hot water. After washing, first with hot water and then with ammonia water until free from sulphates, the residue is dissolved in a little hot dilute hydrochloric acid. The heavy metals, if present, are separated from this solution by means of hydrogen sulphide, first in acid and then in ammoniacal solution. If heavy metals are absent, iron and alumina are separated by the usual ammonia precipitation. The strontium, barium, and calcium are next precipitated by means of ammonium carbonate solution. The carbonates are dissolved in hydrochloric acid, the latter expelled by evaporation, and the solution made just acid with acetic acid and the barium precipitated with ammonium chromate in the usual manner. The strontium

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and calcium are then precipitated from the filtrate from the barium, redissolved and reprecipitated. The latter carbonate is dissolved in nitric acid, the solution evaporated to dryness, and the strontium nitrate separated from the calcium by means of a mixture of equal parts of absolute alcohol and ether (or amyl alcohol), in which the calcium nitrate is soluble. The residue of strontium nitrate may then be dissolved in water and the strontium determined as sulphate.

Sources.

The principal sources of celestite in the past have been the British deposits and those at Westphalia in Germany. The latter deposits have supplied large quantities of celestite, but are now practically exhausted and can not produce in competition with the English workings. The largest supply of the mineral comes from Gloucestershire, England, where it is found in marl deposits and can be easily obtained. The deposits at Strontian, Scotland, are also still productive. The English celestite usually runs about 90 to 95 per cent strontium sulphate.

Strontium minerals have never been obtained to any degree in this country or in Canada until 1916, when some celestite was mined in Arizona and southern California, and what strontium ore is used in this country is largely imported. Both celestite and strontianite are found in many localities in America, however, but most of the deposits are too small to work and others are inaccessible to transportation facilities. Among the localities where strontium minerals are found may be mentioned:—

Ottawa Co., Ohio.
Mineral Co., W. Va.
Monroe and Wayne Counties, Mich.
Maricopa Co., Ariz.
Travis Co., Texas.
Emery County, Utah.
Skagit Co., Utah.
San Bernardino Co., Cal.

Manufacture of Strontium Salts.

The principal commercial salts of strontium are the hydrate, the nitrate, and the chloride, while the bromide is used in medicine. Practically all the compounds of strontium, as we have said, originate from celestite, and the general process employed is similar to that used for the production of barium compounds from barite and is as follows:—

The celestite is hand picked and washed if necessary to free it from clay and other impurities of like nature. This latter is usually done at the mine by crude log washers. If calcium sulphate has to be removed, the ore may be crushed and leached with dilute sulphuric acid, by which treatment the gypsum or calcite is dissolved.

The ore is next dried, mixed with one-third of its weight of coal and finely pulverised. The mixture of coal and celestite is next fed into a furnace and heated to about 2000° C. in a reducing atmosphere. By this treatment the strontium sulphate is reduced to the sulphide, according to the following reaction:—$SrSO_4 + 2C_2 = SrS + 4CO$.

The resulting sulphide usually contains some unconsumed carbon and unreduced sulphate and the impurities in the ore. It is technically known as "*black ash*." The reduction is not entirely complete, but usually amounts to about 60 to 80 of the strontium sulphate present. Some strontium oxide and carbonate are also produced.

The types of furnace used are varied. The ordinary reverberatory furnace is generally employed, while occasionally a small roaster of the Bruckner type is used. A more modern furnace would be along the lines of the rotary cement kiln.

The reverberatory furnace consists of a hearth about 4 to 8 feet wide and from 10 to 20 feet long, heated by a furnace at one end. The mixture of ore and coal is spread in a thin layer on the hearth and rabbled with iron rakes at occasional intervals. The mass is heated by the products of combustion which pass over it and are deflected down upon it by the arch of the furnace. Reducing conditions are aimed at and a temperature of about 2000° F. is maintained.

The Bruckner roaster consists of a short steel cylinder lined with fire brick, about 6 feet to 10 feet in diameter and 10 to 20 feet long. This revolves on bearing rings, or tires, which rest on flanged wheels or rollers. The cylinder is revolved by means of a girt gear and pinions. There are openings at the two ends. At one end of the cylinder a furnace is placed and at the other end a chimney. The products of combustion are led from the furnace into the cylinder and out at the other end to the chimney through the openings in the ends. The charge is introduced and drawn by means of a manhole in the side of the furnace, which is then closed by a cover. In using the roaster the ore is charged into the manhole, the latter closed and the roaster revolved until most of the coal is burned out; usually about two hours are consumed in this heating. The manhole cover is then removed and the charge dumped by revolving the furnace.

The cement, or "rotary," kiln consists of a long steel cylinder lined with fire brick revolving as does the roaster on rollers. It is pitched slightly, however, from the horizontal so that material fed into it at one end will gradually work its way through the furnace and out at the other. The length of the kiln is usually at least ten times its diameter. The heat is supplied by a jet of burning fuel, preferably oil or gas, at the lower end. The material is fed in at the upper end and works its way out at the lower; as it descends it becomes heated to a high temperature and reduction takes place. The time in the furnace can be regulated by the speed of revolution of the kiln and also by the pitch of the latter, and usually amounts to about one hour. A kiln 5 feet diameter by 50 feet long should reduce about twenty tons of celestite in twenty-four hours.

The hot gases emerging from any of the above furnaces are sometimes utilised for evaporation of the solutions by leading under iron pans supported on a brick flue and sometimes are led through a boiler and used to produce steam.

The black ash may be cooled in a pile or it may be placed directly in water in the leachers and so cooled. The leachers consist of iron boxes with a perforated metal plate or screen near the bottom. On this plate is placed burlap bags and then a layer of clean boiler ashes and on top of the ashes the black ash is dumped. Water is now poured the black ash and the strontium sulphide dissolved out. The latter is quite soluble and fairly strong solutions can be produced. The black ash is next washed free from the sulphide with hot water. This wash water can be either added to the strong sulphide solution obtained by the first leaching of the black ash, or preferably it may be kept and used to leach a fresh lot of ash.

The solution from the leachers is pumped or run into steel settling tanks, sometimes provided with steam coils, where any particles of black ash, &c., which have run through the filter bed in the bottom of the leachers are allowed to settle. This solution is free from iron but would contain barium and calcium if present in the ore. The clear solution is then ready for conversion into other compounds of strontium.

If the carbonate or hydrate is to be made the clear solution of the sulphide is run into wooden tanks provided with agitators, where the strontium is precipitated as carbonate by means of soda ash, practically the theoretical quantity necessary being added for this purpose. The precipitate is allowed to settle and the liquid above it drained off. The sodium sulphide in the latter may be recovered by evaporation and sold to tanners, &c. In the latter event the solution is evaporated in iron pans, heated by the waste gases from the furnace, when a fused product containing 40 per cent water is obtained.

The precipitated carbonate is now washed with water by decantation several times and filtered off by means of a filter press. If carbonate only is desired the filter press cakes are dried in a tunnel dryer, through which air from

a fan heated by steam coils circulates, or else in a closet dryer heated by means of steam pipes, &c. The cakes are then crushed and pulverised, when the carbonate is ready for the market.

If hydrate is to be produced the filter press cake is cut into blocks, dried and ignited at about 1200° C. in some form of shaft kiln. No doubt the rotary kiln described previously could be used for this purpose, but so far this has not been done. The oxide so produced is slaked with water for the production of the hydrate.

Another method of converting the sulphide into carbonate is by treating the solution with carbon dioxide gas. This is usually effected by allowing the sulphide solution to pass down through an ordinary absorption tower, ascending through which is a current of chimney or kiln gases rich in carbon dioxide. Strontium carbonate and hydrogen sulphide are produced thereby. The objection to the above method is the formation of hydrogen sulphide, and so long as there is a good market for sodium sulphide the precipitation method is the simpler of operation.

The hydrate can be produced directly from the sulphide by adding sodium hydrate to the latter solution and cooling, when the strontium hydrate crystallises out. The mother liquor is then concentrated further by evaporation, when the balance of the strontium hydrate separates on cooling. Both the strontium sulphide and caustic soda solutions should be saturated.

In preparing the nitrate the sulphide solution may be treated directly with nitric acid, in which case the hydrogen sulphide must be taken care of, or the simpler plan of dissolving the precipitated carbonate in nitric acid may be resorted to. If nitric acid is added to the solution of strontium sulphide the operation is usually conducted in closed vats and the hydrogen sulphide evolved is drawn off by a fan and burned by passing through a coke fire. When the nitrate is prepared the yield may be increased somewhat by leaching the black ash with very dilute nitric acid after leaching with water. This treatment dissolves any strontium carbonate in the black ash. The nitric acid solution then contains iron, which may be precipitated by treating the solution with a slight excess of strontium carbonate or sulphide, when the iron will be precipitated.

The carbonate may be produced directly from celestite by boiling the latter with sodium carbonate solution. Since strontium sulphate is slightly soluble in water the mineral is gradually converted to the carbonate according to the reaction—$SrSO_4 + Na_2CO_3 = SrCO_3 + Na_2SO_4$.

The carbonate can then be filtered off and treated as above.

This process is employed by one American manufacturer.

Uses.

At the present time a limited quantity of strontium salts is used in this country, where practically the sole employment is in the manufacture of fireworks, signal-lights, and signal shells. The most important purpose for which strontium salts are used abroad has never been developed in this country; namely, the strontia or Scheibler process for the recovery of sugar from beet sugar molasses. Germany at the time of the outbreak of the war was using annually in the beet sugar industry from 100,000 to 150,000 tons of strontium hydroxide. (This does not represent the consumption of hydrate in the German sugar industry, as most of that used is recovered as will be explained later on). In Russia also, where the beet sugar industry is well established, probably as great an amount was used. In Italy, Great Britain, and the United States, however, the lime or Steffens process is the one usually employed. It is generally conceded that the strontia process is more efficient than the lime process, and that the principal difficulties connected with its establishment in this country have been the cheapness and facility with which lime could be obtained on the one hand and the expense and difficulty of obtaining strontium hydrate on the other. In the case of lime, too, this is generally discarded after being used, while, owing to the expense, strontia must be recovered.

In view of the present high price of sugar and the need of employing the most efficient process for its recovery, now would seem to be an excellent time to introduce the strontia process into this country. With the introduction of this process the need for strontia would increase enormously over the present demand.

Mr. H. E. Zitkowski estimates that about 150,000 tons of beet sugar molasses are desugarised annually. For this purpose approximately 150,000 tons of strontium hydrate would be required. Of course most of this is recovered, but assuming a loss of 5 per cent, which is not far from the truth, the total quantity of strontium hydrate consumed in this industry would amount to 7500 tons—a quantity many, many times exceeding our present consumption. To the commercial manufacturer entering the strontium salt fields, therefore, the prospect of developing such a market among the beet sugar producers should be an incentive to much missionary work in this latter industry. No doubt the failure of the American sugar manufacturer to consider more favourably the strontia process has been due, in part at least, to the feeling that the strontium hydrate supply was too far away and too uncertain for him to supply his present methods by even a more efficient one using such an unassured raw material.

As I have said, the principal use of strontium in this country is in the manufacture of fireworks, night-lights, and signal shells, in which its sole function lies in the brilliant crimson colour which it imparts to the flame. It is probable that the quantity used in fireworks is relatively small, but the quantity used in the signal-lights which are used by railway and steamship companies is quite appreciable. Since the war began there has unquestionably been a considerable demand for strontium nitrate to be used in signal shells, and it is probable that this, as well as the cessation of importations, has occasioned the increase in the domestic production in the last few years.

To produce red lights strontium nitrate is usually mixed with chlorate of potash and sulphur, a standard formula being potassium chlorate 30 parts, sulphur 16 parts, charcoal 2 parts, strontium nitrate 46 parts, and antimony sulphide 6 parts. For the production of signal shells it is stated that ammonium picrate and strontium nitrate are used, by which means a very brilliant and powerful scarlet flame is obtained.

The salts of strontium are used to a very limited extent in medicine. The principal salts being the bromide, iodide, and salicylate. All three of these are listed in the Pharmacopœia. Of these three salts the bromide is used quite extensively as a nerve sedative in epilepsy, nervousness, hysteria, &c.; the iodide in heart disease, scrofula, &c., and the salicylate in rheumatism and gout. Strontium salts are used in place of the corresponding potassium salts, and are supposed to be less injurious to the stomach, and consequently to be preferred to potassium salts where continuously to be taken.

The use of strontium salts for the extraction of sugar from beet molasses is very old and was proposed by Dubrunfaut as far back as 1849, and it was established shortly after this at a sugar refinery in Dessau. The modern process, however, was originated by Scheibler, who developed it and made it public. Beet molasses contains from 45 to 50 per cent of sugar. This sugar can not be recovered by crystallisation on account of the numerous impurities in the molasses. Strontium salts, however, form insoluble saccharates, which separate and are then decomposed by carbon dioxide with the formation of sugar and strontium carbonate, which latter is reconverted to the hydroxide by ignition. The details of the process in a general way are as follows:—

A 20 to 25 per cent solution of strontium hydrate is first prepared by boiling in a suitable tank provided with steam coils and stirrers. The molasses is next added in amount equal to about one-third of that of the strontium solution, while the latter is stirred rapidly and heated,

Strontium hydroxide is next introduced as needed in such amount that the mass has 12 to 13 per cent of excess alkalinity. The quantity of strontium hydroxide bears the relation to the sugar in the molasses of about the proportion 2·5 to 1. The heating is continued at 100° C. The dibasic strontium saccharate, $C_{12}H_{22}O_{11}.2SrO$, is precipitated. This latter is filtered rapidly, while hot, through bag-filters and washed with boiling 10 per cent strontium hydroxide solution, the latter being recovered from the filtrate. The saccharate is then dissolved in a cold strontium hydroxide solution, and the solution introduced into crystallisers where the temperature is reduced and kept below 10° C. In the course of three days approximately one-half of the strontium hydrate separates in a crystalline form, when the sugar solution containing the balance of the strontia is decanted. The residue of strontium hydrate crystals is centrifuged and the crystals washed with cold strontium hydrate solution and used on another lot of molasses. The sugar solution is mixed with the washings from the strontium hydrate crystals, and the mixture is then saturated with carbon dioxide until it shows a slight alkalinity, all the strontium being thus precipitated as carbonate. The latter is collected on a filter and the sugar solution obtained is either mixed with beet juice in the factory or is concentrated and boiled alone for the crystallisation of the sugar, this latter being placed directly on the market without being refined.

The strontium carbonate recovered is obtained in the form of filter press cakes, which are cut into blocks and burnt in a suitable shaft kiln. There is no doubt, if this process should be adopted in this country, that this calcination could be effected much better in the rotary cement kiln, as this is used at present for the reburning of calcium carbonate waste from the recovery of beet sugar by the lime process.

The American Industry.

At the present time an American strontium industry is in the process of formation. Several of the older chemical companies are making small quantities of strontium compounds, chiefly the nitrate, and two or three plants in Southern California have been established especially for this purpose. These plants do not entirely take care of the present domestic demand, which it is estimated amounts to approximately 1,000,000 pounds, or about 500 tons. This demand is no doubt due largely to war conditions, as the use of signal lights both on sea and land has been enormously increased thereby. The price of nitrate under normal conditions is about 8 cents per pound, but the war prices have fluctuated between 20 and 50 cents, with about 35 cents as an average. The price of the carbonate is about 18 cents for the technical grade.—*Mineral Foote-Notes*, February, 1918.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, February 21, 1918.

Sir J. J. Thomson, O.M., President, in the Chair.

Papers were read as follows:—

"*Scattering of Light by Spherical Shells, and by Complete Spheres of Periodic Structure, when the Refractivity is small.*" By Lord Rayleigh, O.M., F.R.S.

The problem of a small sphere of uniform optical quality has been treated in several papers. In general, the calculations can be carried to an arithmetical conclusion only when the circumference of the sphere does not exceed a few wave-lengths. But when the relative refractivity is small enough, this restriction can be dispensed with, and a general result formulated.

In the present paper some former results are quoted, but the investigation is now by an improved method. It commences with the case of an infinitely thin spherical *shell* from which the result for the complete uniform sphere is derived by integration. Afterwards application is made to a complete sphere of which the structure is symmetrical, but periodically variable along the radius, a problem of interest in connection with the colours, changing with the angle, often met with in the organic world.

"*Nature of Heat as directly Deducible from the Postulate of Carnot.*" By Sir Joseph Larmor, F.R.S.

The germinal idea which developed, in the mind of Sadi Carnot in 1824, into the dynamical theory of heat, was that heat can give rise to motive power only in the process of carrying through its effort towards an equilibrium. A proof is now offered that Carnot's principle regarding heat-engines follows from this basic idea by itself alone, without requiring the introduction of any hypothesis as to the physical nature of heat. It then further follows, from applying the same Carnot formula both to direct and to reversed working, that a scale of measurement of heat can be assigned; *i.e.*, an ideal calorimetric substance can be chosen, so that the heat which disappears shall be the equivalent of the motive power that is gained, and conversely; that is, it follows that heat must itself be a form of energy. But a limiting case of this general result requires separate statement from the physical point of view, viz., the ratio of equivalence between heat and work may be so small that practically the heat is conserved as if it were a substance, and then the work may be said to be done by its fall to a lower potential, strictly after the analogy of the fall of water to a lower level. Finally, a second absolute scale of measurement, that of the potential or temperature of heat, may be chosen which reduces the thermodynamic relations to the standard simple form.

It is also remarked that the original Carnot idea involves immediately the complete foundation of chemical physics as applied to isothermal processes; for under isothermal conditions it asserts that the interchanges of heat that occur during physical or chemical transformations do not enter at all into the interchanges of motive power; that is, of isothermal available energy. But physical knowledge was not wide enough for a dozen years after 1824 to enable any general survey of the energies of nature to be thought of, and when the principle of the conservation and interchanges of total available energies come into the light through the theoretical explorations of Faraday, J. R. Mayer, and Helmholtz, and especially the practical experimental work of Joule, founded mainly on the relations of energy to heat, the Carnot restriction to uniform temperature was tacitly involved, though not overtly expressed until later.

As a chapter in scientific method, it seems desirable to bring into view, even now, the full potentiality that was latent nearly a century ago in the single creative idea of Carnot.

"*Curved Beams.*" By J. J. Guest.

Previous investigations upon the stresses produced in a curved beam by a bending moment have not resulted in solutions satisfying the necessary elastic relationships.

The author first treats the case of a beam which is narrow in proportion to its depth, obtaining expressions for the displacements and principal stresses. The results are then thrown into forms suitable for calculation, and Table I. and Fig. 2 given, whereby the maximum stress produced in any case can be obtained by a simple calculation. The values of the principal stresses at various points of a beam in which the inner radius is one-tenth of the outer radius are given in *Fig.* 3. In this case the stress at the outer radius is 0·26, and the maximum value of the radial stress 0·30 of the maximum circumferential stress which occurs at the inner radius.

For the case of a wider beam the author then shows that for the third principal stress to be zero, both the inner and

outer surfaces of the beam section must curve in a definite manner, depending upon the value of Poisson's ratio for the material used. The displacements and stresses are obtained, and in Fig. 4 the boundary curves are drawn for a mild steel beam having the central section curved as in the example above. Curves showing the principal stresses at a distance from the central plane are given.

The rigorous solution for the case of a very wide beam compelled by restraints to preserve a cylindrical form as it bends is then given.

The paper concludes with a semi-graphical method for estimating the maximum stress occurring in other cases, that of a beam of circular section being worked out for different values of the curvature.

"*On Monoclinic Double Selenates of the Iron Group.*" By Dr. A. E. H. Tutton, F.R.S.

In this memoir are described the results of a complete investigation of the crystals of the potassium, rubidium, cæsium, and ammonium salts of the iron group of double selenates of the series—

$$R_2M\left(\begin{matrix}S\\Se\end{matrix}O_4\right)_2.6H_2O.$$

It has been rendered possible by the success which has at last attended the author's prolonged attempts to prepare ferrous selenate, and especially potassium ferrous selenate, as described in the preceding paper. The outstanding result is to confirm the conclusions drawn from the previous study of three other groups of double selenates, and of eight groups (the complete set) of double sulphates.

The general law of progression of the crystallographic properties, with the atomic weight and atomic number of the interchangeable alkali metals which form the group, is obeyed absolutely rigidly by the iron group. The change in the principal (monoclinic axial) angle, the mean of the changes in all the thirty-eight different angles measured, and the maximum change of angle, are all directly proportional to the change in atomic weight or number. The change in the dimensions of the structural unit cell of the space-lattice, as indicated by the molecular volumes and the topic axial ratios and the molecular refraction (the best measure of the optical refractive power), are properties which progress, with acceleration, with rise of atomic weight and number of the alkali metal.

The key to this interesting crystallographic progression and its logical explanation, so long obscure, has been at last afforded by the brilliant discovery of Moseley, that the atomic sequence number is the expression of the complexity of the atom, and is itself a fundamental constant, a direct measure of the positive electric charge on the atomic nucleus, and of the number of negative electrons clustered around it in electrical equilibrium. Atoms so vigorous as those of the alkali metallic family group, differing regularly by the number of electrons corresponding to two whole horizontal rows of elements of the periodic classification, must naturally exhibit a similarly regularly progressive influence on the structure and physical constants of the crystals of a series of salts in which they are the interchangeable dominating constituents.

The results as regards ammonium ferrous selenate prove conclusively once more that the ammonium and rubidium salts of the same group are almost perfectly isostructural, and equally molecularly refractive.

"*Selenic Acid and Iron. Reduction of Selenic Acid by Nascent Hydrogen and Hydrogen Sulphide. Preparation of Ferrous Selenate and Double Selenates of Iron Group.*" By Dr. A. E. H. Tutton.

Some new properties of selenic acid have been observed. Instead of dissolving iron with evolution of hydrogen like sulphuric acid, selenic acid is without appreciable action on iron. After a very long time the latter becomes thinly coated with red selenium due to reduction of a trace of the acid by nascent hydrogen produced in the slight action which occurs. The net result of this very small amount of reaction is $3Fe+4H_2SeO_4=3FeSeO_4+Se+4H_2O$.

The author has found, however, that ferrous selenate can be readily prepared by the action of selenic acid on ferrous sulphide, $FeS+H_2SeO_4=FeSeO_4+H_2S$. The hydrogen sulphide preserves the product in the ferrous condition. A slight secondary reaction also occurs, for sulphuretted hydrogen reduces selenic acid with precipitation of both sulphur and selenium, $3H_2S+H_2SeO_4=Se+3S+4H_2O$, contrary to the statements of Mitscherlich and the text-books. On filtration the green solution contains pure ferrous selenate from which monoclinic crystals of $FeSeO_4.7H_2O$ are deposited, but which rapidly decompose. The solution, however, mixed with an equivalent of rubidium selenate, cæsium selenate, or ammonium selenate, deposits excellent permanent crystals of the monoclinic double selenates with $6H_2O$. But if mixed with potassium selenate no potassium ferrous selenate crystals are obtained at all under ordinary circumstances. After attempts spreading over eight years the author has at last obtained $K_2Fe(SeO_4)_2.6H_2O$ crystals during four of the very cold nights of January, 1918, when the laboratory temperature fell to nearly 0° C., and never rose above 2° C. Above this temperature the salt is unstable. The crystals were pale green, well formed, and clear, but only lasted at most five hours after removal from the mother-liquor, becoming opaque white, like porcelain. By intensive work, using special methods, on the four days succeeding the cold nights referred to, the crystallographic investigation of the salt has been completed, and the results are communicated, together with those for the other three salts of the iron group, in the succeeding memoir.

PHYSICAL SOCIETY.

Ordinary Meeting, February 22, 1918.

Prof. C. H. Lees, F.R.S., President, in the Chair.

A paper, entitled "*A Note on the Use of Approximate Methods in obtaining Constructional Data for Telescope Objectives,*" was read by Mr. T. Smith.

The paper discusses the reason why satisfactory telescope objectives are obtained by neglecting thicknesses, and solving for freedom from first order aberrations. It is shown that the introduction of thicknesses into such an objective without any alteration in the curvatures of the surfaces yields a lens corrected for aberration for a zone which is a constant fraction of the full aperture obtainable. For objectives of the usual type this zone is very approximately the one that would be selected for correction to obtain the most favourable balance between first and second order aberrations. It follows that objectives calculated from first order formulæ in which thicknesses are neglected do not require trigonometrical verification or correction unless the conditions are very abnormal.

Discussion.

Prof. J. W. Nicholson said that the author had brought out an important point in this paper. There was an idea prevalent in many quarters that the thin lens was simply an abstraction of no practical importance, but apparently this was by no means the case. He had been familiar in a general way with this compensation of first and second order aberrations, but had never seen it mentioned in any publication. Were there any convenient circumstances in which both coma and spherical aberration are simultaneously compensated for the same aperture?

Prof. C. H. Lees asked how the magnitude of the residual aberration or the shape of the aberration curve altered when the zone of correction was altered by changing the index of the crown glass.

The Author, in reply to Prof. Nicholson, said he had not worked out numerical cases for coma, though the formulæ were quite simple. In practice, it is usually found that in the absence of spherical aberration if the coma is approximately corrected the result is satisfactory. He had no

doubt, however, that with triple objectives both coma and spherical aberration could be compensated for the same aperture. In reply to the President, generally speaking, with very low indices of the crown the second order aberration is large, while with indices nearer the flint it is smaller. The ratio of extreme cases might be about 5 to 1.

A paper, entitled "*A Suggestion as to the Origin of Spectral Series*," was read by Dr. H. Stanley Allen.

The note gives a development of an idea put forward in an earlier paper, describing an atomic model with a magnetic core. It is assumed that the principle of the constancy of angular momentum may be applied to the *total* angular momentum of the electron, and a certain part of the core bearing a special relation to the electron. On the lines of Bohr's theory this leads to an expression for the oscillation frequency, which is similar to Rydberg's formula, and contains a constant which is the same for all elements. The "phase" μ of a "sequence" is regarded as proportional to the angular momentum of a definite portion of the core. In observed series the phases of the two sequences are not equal to one another; consequently, whatever interpretation be given to the phase, the two types of state concerned must be in some way different from one another. When the magnetic field of the core is taken into account, a formula is obtained which is identical with that of Ritz. An explanation of the series of enhanced lines in spark spectra is also suggested.

Discussion.

Prof. J. W. Nicholson thought the fundamental assumption in the paper seemed a natural one. Bohr's theory, in the case of hydrogen, assumed the angular momentum to be proportional to the integers in Balmer's series. In the case of more complex atoms we were compelled to assume that $\tau+\mu$ is the quantity to which the angular momentum is proportional. To consider the extra angular momentum to be attached to the nucleus is, of course, another assumption. It is equivalent to attaching a physical significance to tubes of force, which Sir J. J. Thomson has always tried to do. An interesting feature of the theory was that it gave the series of enhanced lines of spark spectra, and the physical interpretation of $k=2$, viz., that these are due to atoms with another electron torn off, seemed very feasible. As was pointed out in the paper, any theory involving stationary states must allow for different types of stationary state—*i.e.*, different values of μ_1 and μ_2. The considerations by which Rutherford deduced the smallness of the nucleus were founded on the mathematical work of Darwin, and on the assumption that the nucleus is wholly electrical are faultless. The fact that the nucleus might be magnetic was pointed out by Hicks, who showed that the scattering of α-particles by atoms might be accounted for by magnetons rather than electrons.

Prof. G. W. O. Howe asked what was the reason for applying the word "phase" to μ. To an electrician phase had a very different meaning. What was the significance of the initial equations with which the paper started out?

Prof. Lees asked if the atom suggested by Dr. Allen would give the same scattering effects as had been experimentally found?

The Author, in reply, said the term "phase" was due to Rydberg, and was introduced before the Quantum Theory was evolved. He did not know why the term had been selected. He was afraid he could not answer Prof. Howe's second question. These equations were fundamental to the Quantum Theory, and to understand them fully one would have to *know all about Quanta and the* constitution of matter. With regard to the scattering of α-particles, he thought it was possible to explain this as done by Hicks, if we take into account the magnetic action of the core. Of course, the electric action is also there, and has to be taken into account as well. The results of experiments on scattering do not preclude the introduction of magnetic forces.

CHEMICAL SOCIETY.

Ordinary Meeting, February 7, 1918.

Prof. W. J. Pope, C.B.E., F.R.S., President, in the Chair.

Reference was made to the loss sustained by the Society, through death, of the following Fellows:—Richard Lilburn Barnes, John Forbes Bell, and John Scudamore Sellon.

Certificates were read for the first time in favour of Thomas Thompson Best, Ph.D., "Woodleigh," Laurel Road, St. Helens; Rudolph Isaac Blackburn, B.A., B.Sc., 8, Dunlace Road, Clapton, E. 5; Cyril Bride, B.A., B.Sc., 86, Ridgeway, Edgbaston, Birmingham; Prof. Giuseppe Bruni, Corso Buenos Ayres, 55, Milan; Colin Campbell, M.Sc., 45, Heywood Street, Alexandra Park, Manchester; John George Clarke, M.A., B.Sc., 12, Rhodesia Road, Leytonstone, E. 11; Frederick Charles Duggleby, 87, Loughborough Park, Brixton, S.W. 9; Francis John Dymond, B.Sc., 6, Lockyer Street, Plymouth; Owen Charles Edwards, B.Sc., 46, Saxon Road, Faversham; Thomas Greetham, Finch Villa, Millom, Cumberland; Henry Francis Everard Hulton, F.I.C., 15, Oakhill Court, East Putney, S.W. 15; Julius Jung, 14, Bancroft Road, E. 1; Benjamin Llewellyn, M.Sc., Lt., A.O.D., 11, St. Silas Street, Ardwick, Manchester; William Alexander Montagu, Lt. H.L.I., 7, Garturk Street, Crosshill, Glasgow; Harry Singer, 147, Upper Clapton Road, E. 5; Maurice Smith, J.P., care of Messrs. Cuxsom, Gerard, and Co., Ltd., Oldbury; Stephen Veitch Telfer, M.B., Ch.B., 533, Crosshill Road, Crosshill, Glasgow; Walter Arthur Voss, "Fairlight Glen," Eastwood Road, Rayleigh, Essex; Harry William Webb, M.Sc., 29, South Road, Smethwick, B.O., Staffs.; James Wood, M.A., B.Sc., care of Research Department, C.W.S., 109, Corporation Street, Manchester.

The following papers were read:—

"Some Inorganic Stannichlorides." By J. G. F. Druce.

"A Reinvestigation of the Cellulose—Dextrose Relationship." By Miss M. Cunningham.

"Esparto-cellulose and the Problem of Constitution." By C. F. Cross and E. J. Bevan.

Extract from the Report of Council, 1917-1918.

The Council are gratified to report a substantial increase in the number of Fellows during the past year. On December 31, 1916, the number of Fellows was 3198. During 1917, 162 Fellows were elected, and 9 reinstated, making a gross total of 3369. The Society has lost 39 Fellows by death, 13 have resigned, the elections of 2 have been declared void, and 45 have been removed under the action of By-law IV. for non-payment of annual subscriptions. The net total number of Fellows, therefore, as at December 31, 1917, was 3270, showing an increase of 72. During 1916 there was a decrease in membership of 5.

The hearty congratulations of the Society are offered to Sir William Crookes, Past-President, elected a Fellow on December 3, 1857, and to Mr. John Frederick Davis, elected December 17, 1857, who have now been Fellows for over sixty years.

Heat Conductivity in Fire Bricks.—*As a test of* friability in fire bricks a sample after manufacture heated to a red-heat and cooled to 200° C. externally, and an approximate internal temperature of 500° C., may be buried in sawdust; when the temperature during slow combustion of the latter rises to a red-heat in the latter a good brick, on taking out after cooling, should not be friable.—J. C. Thomlinson, B.Sc.

MISCELLANEOUS.

Appointment.—Dr. Sophie Bryant was appointed a Life Governor of the Great Northern Central Hospital by the Committee of Management on Thursday, March 7, 1918.

Tin and Tungsten Research Board.—As the outcome of a Conference held on November 7, 1917, at which there were present representatives of the Committee of the Privy Council for Scientific and Industrial Research of the *Department for the Development of Mineral Resources*, and many of the Land and Mine-owners of Cornwall, a fund for research has been raised, and a Research Board has been appointed by the Committee of the Privy Council consisting of—

Sir Lionel Phillips, Bart. (Chairman).
Mr. John G. Gilbert, Cornish Chamber of Mines.
Sir Frank Heath, K.C.B., Department of Scientific and Industrial Research.
Sir Thomas Kirke Rose, Chairman of the Research Committee of the Board.
Mr. Edgar Taylor, Institution of Mining and Metallurgy.
Mr. R. Arthur Thomas, Cornish Chamber of Mines.
Sir Richard Threlfall, K.B.E., F.R.S., Advisory Council *for Scientific and Industrial Research.*
With Mr. A. Richardson as Secretary (15, Great George Street, Westminster, S.W. 1).

The Board after consultation with their Research Committee have authorised extended lines of research with a view to increasing the recovery of metal in the treatment of ores.

Educational Lectures for Wounded and Convalescent Soldiers.—Some weeks ago several wounded men at the Great Northern Central Hospital made up their minds to organise lectures on Educational subjects, chiefly technical. Private Mallet, who, before volunteering early in 1915, was a student *in training as a teacher of handicraft* at the L.C.C., Shoreditch Technical Institute, approached on behalf of these men the Hospital authorities, and through Principal S. Hicks some members of the Staff of the Institute. At a meeting held at the *Hospital the men stated very clearly what they feel they need.* Some few want books and guidance in taking up again and continuing their pre-war studies in such subjects as Industrial Chemistry, Mathematics, Accountancy, Education, &c. Some asked for one or two lectures on Gardening *or Agriculture*; others are anxious to know something of the training that might be given them in Boot Making, Cabinet Making, Wood-carving, Picture-frame Making, Bookbinding, &c. Many are interested in commercial work, others in architecture, while some ask for guidance in the study of English literature. Mr. Harris, Chief Librarian at the Islington Central Library, has kindly offered his services and expert advice in supplying standard technical books *on loan to soldiers, and a course of* lectures on many of the above subjects will be begun at once. Mr. P. A. Wells, Head of the Cabinet Making Department of L.C.C. Shoreditch Technical Institute, commence the series by giving a lantern lecture on "Furniture" on Friday, March 8. *The Principal of the Institute will* give a lecture on the "Fisher Education Bill and the Need for Technical Teachers." Whenever possible the speakers will be men who have had experience as practical craftsmen or teachers or both, and they will be able to answer the very relevant questions the soldiers have to ask. The authorities of the Great Northern Central Hospital are inviting to these lectures soldier out patients, discharged men, and convalescent soldiers from other hospitals. Mr. A. Rowan, Normal Master, Training of Teachers Department, L.C.C. Shoreditch Technical Institute, has volunteered his services as adviser in connection with educational and allied occupations.

MEETINGS FOR THE WEEK.

TUESDAY, 19th.—Royal Institution, 3. "The Climatic Adaptation of Black and White Men," by Dr. Leonard Hill.
—— Institution of Petroleum Technologists, 8. "The Russian Petroleum Industry and its Prospects," by D. Ghambashidze.
WEDNESDAY, 20th.—Royal Society of Arts, 4.30. "Agricultural Machinery," by F. S. Courtney.
THURSDAY, 21st.—Royal Institution, 3. "War Music—Past and Present," by Sir Alexander Mackenzie.
FRIDAY, 22nd.—*Royal Institution*, 5.30. "Radiation from System of Electrons," by Prof. Sir J. J. Thomson, O.M.
SATURDAY, 23rd.—Royal Institution, 3. "Problems in Atomic Structure," by Sir J. J. Thomson.

TO comply with Regulation 8 (*b*) of the Defence of the Realm Act, advertisements from firms whose business consists *wholly or mainly in Engineering, Shipbuilding, or the production* of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Analytical Chemist (Food) wanted for London (male or female).—Apply to L. MacQueen Douglas, 29, West Savile Terrace, Edinburgh.

Chemist (Analytical and Metallurgical) with Works experience requires Post.—Address, P. B., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemists (Men or Women) wanted, with University Degree or its equivalent, for an Explosives Factory in the South of England.—Box 626, Leathwait and Simmons, 5, Birchin Lane, E.C. 3.

WOMEN ANALYTICAL CHEMISTS required at salary of £150 per annum in Government Department in South of England. Annual and Sick Leave allowed. Other Women Chemists employed. Salary to be increased to £175 per annum at end of six months if services are found to be satisfactory —Address, C. W., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

CITY AND GUILDS TECHNICAL COLLEGE, FINSBURY.

DEMONSTRATOR IN APPLIED CHEMISTRY.

The above appointment under the City and Guilds of London Institute is vacant. Salary £160.—Applications, stating qualifications, should be addressed to Prof. G. T. MORGAN, D.Sc., F.R.S. A copy of the terms and conditions attached to the appointment may be obtained on application to the Acting Registrar, City and Guilds Technical College, Leonard Street, Finsbury, E.C. 2.

PORTSMOUTH EDUCATION COMMITTEE (HIGHER EDUCATION).

PORTSMOUTH MUNICIPAL COLLEGE.
CHEMISTRY AND NATURAL SCIENCE DEPARTMENT.

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THE CHEMICAL NEWS

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A NEW METHOD OF DETERMINING COPPER.

By JAMES MOIR.

The object of the author in inventing this process was to ind a method of doing without the large quantities of the xpensive potassium iodide required in the ordinary ccurate process for copper. For example, if high ccuracy is required in determining the true percentage of opper in a "pure" copper, about 4 gr. of the metal must e taken, involving the use of about 30 grms. of KI and 6 grms. of crystallised thiosulphate.

Now, if the equations concerned in the ordinary process e studied, it will be seen that the net result of the addi ion of iodide and thiosulphate to cupric acetate is to pro uce an insoluble cuprous salt along with a soluble :trathionate.

$$1.\ Cu\bar{A}_2 + 2KI = CuI + 2K\bar{A} + \tfrac{1}{2}I_2.$$

$$2.\ \tfrac{1}{2}I_2 + Na_2S_2O_3 = NaI + \tfrac{1}{2}Na_2S_4O_6.$$

The net result is as if the equations were—

$$3.\ Cu\bar{A}_2 + KI + Na_2S_2O_3 = CuI + K\bar{A} + Na\bar{A} + \tfrac{1}{2}Na_2S_4O_6.$$

It therefore struck me that the simple direct reaction etween cupric salts and sodium thiosulphate would be orth reinvestigating. Now, a number of double copper odium thiosulphates were described by German authors iirty or forty years ago, but it is probable that the hole of this work is wrong, and that the substances otained were really tetrathionates and not thiosulphates.

When equimolecular solutions of copper acetate (or opper sulphate in presence of acetic acid and sodium cetate) and sodium thiosulphate are mixed, the mixture greenish yellow, and, in my opinion, consists mainly of oluble cuprous tetrathionate, but also contains a propor on of unchanged cupric thiosulphate—

$$4.\ Cu\bar{A}_2 + Na_2S_2O_3 = \dot{C}uS_2O_3{}''2Na\bar{A}.$$

$$5.\ 2\dot{C}uS_2O_3{}'' \rightleftharpoons Cu_2S_4O_6{}''.$$

(Balanced reaction between cupric thiosulphate and cuprous tetrathionate).

Equation 5 is perhaps more intelligible with separate ons.

$$6.\ \dot{C}u + \dot{C}u + S_2O_3{}'' + S_2O_3{}'' = Cu + Cu + S_4O_6{}''.$$

The action being a balanced one is not suitable *per se* r an analytical process; nevertheless, it was obvious at the success of the old iodide method depended on the most complete insolubility of the cuprous salt produced, se the above balanced reaction would occur. This was onfirmed on trying to replace iodide with bromide or iloride (the cuprous salts of which are fairly insoluble), hen it was found that the reaction was incomplete. owever, on trying sulphocyanide (thiocyanate) as a sub itute for iodide success was obtained. The above lanced reaction then goes entirely in the direction of iprous tetrathionate because the cuprous ion is removed insoluble CuSCN as fast as it is formed, and on filtra on a *colourless* solution containing only $Na_2S_4O_6$ and cess KSCN and $Na_2S_2O_3$ is obtained, in which under ecial conditions the latter can be estimated with iodine en in the presence of sulphocyanide.

The analytical process suggested is therefore as follows: Dissolve the weighed specimen in HNO_3, and get it to the condition of very faintly acid cupric acetate, either the old methods or by the quick process which I describe ther on. Add a single excess of thiosulphate in known quantity (1 grm. copper requires 3·904 grms. crystallised thiosulphate, or about 158 cc. of "N/10 thiosulphate"), and (immediately) a sufficient excess of potassium sulpho-cyanide (equal to, say, 1½ grms. per grm. of copper). The white precipitate of CuSCN has then to be filtered off, roughly washed, and rejected. Since it goes through every known variety of filter-paper, and since the solution cannot be heated (else the trace of acetic acid would act on the excess thiosulphate) it is necessary to add a quantity of pulped filter-paper before attempting to filter; (this is made by boiling a loose-texture filter-paper in dilute caustic soda until disintegrated and neutralising with acetic acid); on filtering, about 5 cc. will come through turbid before the pulp chokes the pores of the paper, after which a clear filtrate is obtained. As there is very little excess thiosulphate in this filtrate, any *elaborate* washing of the CuSCN precipitate is a waste of time.

To finish the analysis, the filtrate is *first* diluted to about a litre, and then treated with 5 to 10 cc. concentrated pure H_2SO_4 (do not use HCl which, in this country, owing to bright sunlight, always contains free chlorine) and a little starch solution, and titrated back with N/10 iodine, only a small quantity being required if the directions about thiosulphate have been followed. The calculation is merely—

$$\frac{\text{Cc. true N/10 thiosulphate at beginning} - \text{cc. N/10 iodine}}{157{\cdot}3}$$

= copper present (in grms.), assuming 63·6 for its atomic weight. The filtrate must *not* be titrated with iodine without the high dilution and the *mineral* acid, otherwise iodine is absorbed by the excess KSCN present. Iodine does not apparently attack dilute HSCN.

If the approximate percentage of copper in the specimen is *totally* unknown, the experiment must be done twice—(1) on a small specimen (0·1 grm.) using 16 cc. of "N/10 thiosulphate"; (2) repeating using thiosulphate equal to ("thiosulphate" minus iodine) of the first experiment. Thus if experiment (1) used 2·5 cc. iodine at the end, the correct "thiosulphate" for experiment (2) is at the rate of 135 cc. per grm. of material. This means that the method gives high results for copper (102 to 105 per cent of the truth) when a *large* excess of "thiosulphate" has been used, but is sharply accurate when the "thiosulphate" is just in excess.

If *great* accuracy is required, 2 or 3 grms. of specimen must be taken, in which case it is better to weigh out the thiosulphate required (see above). This is because 400 cc. of thiosulphate solution would have to be taken, and the factor of any thiosulphate solution is not generally known within 1 part in 500, besides being variable with temperature. The following is a description of some of my results with the method:—

1. *Analysis of* $CuSO_4.5H_2O$.—0·2500 grm. in water treated with sodium acetate and two drops HA, then with 12·19 cc. "N/10 thiosulphate" of factor 0·985 = 12·01 cc. true N/10 thiosulphate. At the end the diluted acid filtrate required 1·99 cc. N/10 iodine; the quantity of copper is—

$$\frac{12{\cdot}01 - 1{\cdot}99}{157{\cdot}3} = 0{\cdot}0637 \text{ grm. (Theory } 0{\cdot}0636.)$$

2. *"Pure" Copper* (*99·6 per cent by Iodide Method.*—0·1280 grm. dissolved; preliminary trial with 25 cc. thiosulphate used 4·4 iodine (and Cu = 102 per cent!). Second trial with 20·6 thiosulphate (corrected) used 0·54 iodine,—

$$Cu = \frac{20{\cdot}06 \times 100}{157{\cdot}3 \times 0{\cdot}128} = 99{\cdot}7 \text{ per cent.}$$

Third trial with 20·5 thiosulphate used 0·40 iodine; Cu = 99·85. These discrepancies are due solely to the smallness of sample taken, when one drop of reagent makes a difference of ½ per cent in the result for copper. If 1 grm. sample had been taken, an accuracy of 0·03 per cent per drop could have been expected.

3. *Electrolytic Copper (over 99·9 per cent).*—0·1803 grm. dissolved; 29·3 cc. thiosulphate and 0·7 iodine used

in first trial (Cu = 100·7 per cent). In the second trial 28·60 thiosulphate (corrected) and 0·25 iodine; 28·35 difference or Cu = 99·9 per cent.

4. *Copper-Nickel-Tin-Lead Alloy*.—After preliminary trial, 24·66 cc. (corrected) thiosulphate used for 0·2315 sample; iodine used 0·78 ∴ Cu = 65·6 per cent. In this case the foreign metals were not separated and did not interfere, as Prof. Stanley's analysis of this sample by standard methods gave Cu = 65·8 per cent.

Owing to the nature of my process scarcely any of the common metals (except iron) interferes. Only such metals could interfere as are capable of being reduced from their *-ic* condition to their *-ous* condition by dilute thiosulphate, the *-ous* condition being then *not* oxidisable by iodine; so far as I can see, iron is the only metal which fulfils such conditions.

The quick process mentioned above for getting the dissolved metal or ore into a condition for determining the copper depends on the little appreciated fact that nitric acid is not an oxidising agent if nitrous acid is removed from it. According to the ionic theory, dilute *pure* nitric acid consists only of the ions H' and NO_3', the latter of which has no tendency to part with its oxygen unless a strong reducing agent is added.

The metal or ore is dissolved in a covered vessel with *concentrated* HNO_3; the solution is agitated for a minute or two to get rid of as much dissolved NO_2 as possible, diluted to 20 cc., and treated with ½ grm. of urea (carbamide). After the effervescence has stopped the mixture is diluted to 50 cc. and boiled for fifteen seconds. Thereon caustic soda is added to near neutrality, followed by 2 or 3 grms. of solid sodium acetate.

The analysis can then be proceeded with. The destruction of the nitrous acid is explained by the equation:—

$$CH_4ON_2(\text{urea}) + 2HNO_2 = CO_2 + 2N_2 + 3H_2O.$$

—*Journal of the Chemical, Metallurgical, and Mining Society of South Africa*, xviii., No. 5.

THE COST OF COAL.*

A Summary of the Various Elements which Determine It.

By GEO. OTIS SMITH and C. E. LESHER
(United States Geological Survey).

The price of coal is a matter of vital concern to the average citizen. No less important, however, is the question what our coal actually costs to produce, and the interest in this subject is typical of the popular interest in the large productive enterprises of the country. As citizens we recognise the consumer's dependence upon the producer, and are taking advanced ground as to their relative rights. In few industries does this dependence seem more vital or the consumer's equity appear larger than in that of producing and selling coal. The per capita annual expenditure for the useful metals is roughly equivalent to that for coal, but few citizens purchase pig iron or bar copper, whereas of the urban population only the dwellers in apartments, boarding houses, and hotels are spared the necessity of buying coal. The consumption of coal in the United States for heating and cooking is between 1 and 1½ tons per capita. A careful estimate for 1915 is 1·1 tons, which happens to be identical with the figure determined for similar consumption in Great Britain in 1898. This non-industrial consumption is greatest in cities, and in this city of Chicago, in 1912, it was nearly 2 tons. Of course every citizen indirectly pays for his share of the total consumption, which last year amounted to 4·6 tons per capita.

In discussing costs, however, we do not overlook the too evident fact that at times price may far outstrip cost. The price of coal depends upon the balance between necessity for fuel on the one hand and ability to produce and to deliver on the other; the ability to produce is in turn controlled by the labour available and the ability to deliver is dependent upon car supply. Increased foreign demand for American coal, large industrial consumption, unusual weather—all may have great influence on the current price of coal, but none of these is to be considered a factor in the actual cost of production, except so far as it causes irregularity in operating expenses and promotes a decrease in efficiency of mine labour. To-day high prices are being received for coal by those who are able to produce and deliver more than their outstanding contracts require. In other words, a few traders may be able and willing to capitalise the urgent necessity of the consumer and their own ability to deliver.

Four general items of cost must be considered as normally controlling the price of coal to the consumer—resource cost, mining cost, transportation cost, and marketing cost. Under usual conditions each of these items includes a margin of profit which may seem either excessive or inadequate according to your point of view. Yet an unbiased consideration of these cost items is absolutely essential as a preliminary to the decision by the public whether we are buying coal at a fair price, and if not why not. As long as it is the popular view that the price of coal is made up of one part each of mining costs and freight costs to two parts each of operator's profits and railroad dividends, with the cost of a certain amount of needless waste on the side, the demand for investigation will continue, and in so far as there is any element of truth in this view legislative action is justified, even though the prescribed reform may approach the extreme of public ownership and operation of mines and railroads.

As the initial item of cost, the amount charged against the marketed product as the value of the coal in the ground, which for brevity may be termed the resource cost, is perhaps the item most often overlooked by the coal consumer, and for this reason that phase of the subject will be fully considered after the other items are treated. These other items need less discussion in this paper for several reasons—the item of marketing cost is one that can be brought directly under observation by the consumer if he will but study the matter intelligently; the transportation cost can be learned by simple inquiry, and its control lies within the province of the Interstate Commerce Commission, and the details of mining cost can best be set forth by the mine operators themselves, for they have now adopted the policy of free discussion of these matters, which they once regarded as sacred from public view. The purpose of this paper then is simply to give a summary statement of all these elements in the cost of coal, and some special discussion of the resource cost.

The item of cost first to be considered represents that part of the value given to the ton of coal by the mine operator and the mine worker. This may be termed mining cost, but it must include the operator's selling costs and other overhead expenses as well as the mining costs proper, which include the larger expenditures for wages, supplies, and power. The cost plus the resource cost—the royalty or depletion charge—and the profit or loss on the sale make up the value at the mine mouth. The mining cost varies not only between mines of different companies in separated fields, but even between adjacent mines of the same company in the same field. Both nature and man contribute to such variation.

It is not practicable to assign a very exact figure to the mining cost—the census of 1909 indicated an average of 1 dol. a ton for bituminous coal and 1.86 dol. for anthracite, but these figures are believed by some operators to be too low. It is possible, however, to show in a general way the distribution of this item; the cost of mining is divided between labour, 70 to 75 per cent; material, 16 to 20 per cent; general expense at mine and office and insurance, 2 to 4 per cent; taxes, less than 1 per cent to 3 per cent for bituminous coal, and 3 to 7 per cent for

* A paper read before the American Mining Congress, Chicago, November 14, 1916. From the *Scientific American Supplement*, lxxxv., No. 2192.

anthracite; selling expenses, nothing to 5 per cent, and recently to these items has been added the direct and indirect cost of workmen's compensation, which may reach 5 per cent for bituminous coal. The charges for labour, material, and general office expenses are easily understood, as is also a charge for depreciation of plant and machinery; but taxes and selling expenses are important items that may be overlooked by the casual observer. Some figures recently published show that the taxes levied in West Virginia last year on coal lands and coal-mine improvements—that is, on the industry as a whole—were equivalent to nearly 3 cents net per net ton of coal produced, which is doubtless fully as much as the profit made by the operators in that State.

The cost of selling coal is nothing for the companies that use their own product, including the Steel Corporation and a large number of others, and is little or nothing for the producers who sell nearly all their coal to such large consumers as the railroads. Companies that produce coal for domestic use and the general run of steam trade must figure on a selling cost as high as 10 cents or more per ton, the cost depending on the extent of their business. The average selling cost for bituminous coal is probably 5 to 10 cents a ton, and for anthracite the usual charge of sales agencies is reported as 10 cents a ton for steam sizes and 15 cents for the prepared sizes.

The producers of coal and the transportation companies are concerned not so much with the actual rates charged for carrying coal as with the adjustment of rates between different coal fields and between different markets. In the many years in which our coal industry has been developing rate structures have been built up that give to this and that producing district differentials over other districts—"handicaps," as it were—that may be based on comparative lengths of haul or on the ability of the coals to compete by reason of difference in quality or in cost of mining, or perhaps may be merely the survival of past practice, for which no reason now exists. The consumer of coal, however, is interested in the actual rather than the relative freight rate.

To help towards a realisation of the magnitude of this transportation item it may be pointed out, first, that all but 14 per cent of the output of the country's coal mines, aggregating 532 million tons, is moved to market by rail or water, and, second, that nearly half of the bituminous coal (47 per cent in 1915) and more than two-thirds of the anthracite (71 per cent in 1915) is shipped outside of the States in which it is produced.

Add to this statement of the extent to which coal enters interstate commerce a glance at the distribution of centres of maximum production and maximum consumption—the New York Baltimore industrial zone, which has a total per capita consumption of nearly 10 tons and lies 100 to 400 miles from the tributary coal fields; New England, consuming about 7 tons to the unit of population and lying 400 to 800 miles from its coal supply; or the populous industrial district of which Chicago is the commercial centre, consuming 8 or 9 tons per capita of coal, in part hauled more than 400 miles from the fields of West Virginia and eastern Kentucky and in part 200 miles or less from the Illinois mines. With these facts in mind we must realise that the transportation cost is necessarily a large part of the country's fuel bill.

In the interstate traffic, both rail and water, bituminous coal probably pays an average freight of nearly 2 dols. per ton. In other words, the transportation costs more than the product, and, as some parts of the country are just now learning, is sometimes more difficult to obtain. The value of coal, like the value of so many other commodities, is a place value.

The average freight charge on anthracite is higher than that on bituminous coal, first because the rates are higher, and second because, according to the reports of the Interstate Commerce Commission, *all* movement considered, the coal is carried a greater distance.

The cost of handling the coal, exclusive of freight, from the time it leaves the producer until it is in the consumer's fuel bin, may be termed the marketing cost. It can readily be seen that a large part of the coal produced is not subject to this cost, for most large users of steam coal, such as the railroads and the coke manufacturers, place contracts directly with the producing companies or their selling agencies and buy in the open market only when their needs exceed the deliveries under their contracts. Much of the coal, however, both anthracite and bituminous, passes through the hands of a wholesale dealer or jobber before it is received by the retail dealer, who puts it in our cellars or in the bins of a power plant. Coal that gets a long way from the mine may pass through many hands before it reaches the consumer, and it not only pays commissions all along the line, but is subject to shrinkage and deterioration, both of which enter into the final selling price to the consumer. Brokers are usually satisfied to make a gross profit of perhaps 10 cents a ton, but as several brokers may make a "turnover" on the same car before it is unloaded this element of cost may be several times that amount.

About half of the anthracite and around 15 per cent of the bituminous coal is retailed in less than carload lots, and the greater number of individuals are directly concerned in the marketing of this portion, regarding the profits on which there is the widest divergence of opinion. The margin in the retail business between cost on cars and price delivered is between 1.25 dols. and 2 dols. a ton, and is not more than enough to give on the average a fair profit. The shrinkage and in part the deterioration are together seldom less than 1 per cent of the weight, and may exceed 4 per cent, and the retail dealer also must provide in his selling price for uncollectable accounts.

Advertising is a large expense—in part carried by the retailer directly, but all borne by the industry. The largest single item in the cost of retailing is of course that representing the labour of handling and the local cartage, which together make up about half the marketing cost.

There now remains to be considered the first major item, or the resource cost, which is what the operator has to pay for the coal in the ground—the idle resource, which he starts on its career of usefulness. This cost is expressed as a royalty or a depletion charge.

One of the latest leases by a large coal-land owner provides for the payment of 27 per cent of the selling price of the coal at the breaker. This percentage is therefore not only a royalty figured on the mineral resource, but also a commission based on the miner's wage. To bring this right home to you and to me, it may be said that the practical result is that if the anthracite we burn in our range this winter happens to come from that particular property, we will pay fully 1 dol. a ton into the treasury of the city trust that owes its existence to the far-seeing business sense of a hard-headed citizen of Philadelphia. Whether such a royalty is excessive or not the fact remains that this is the tribute paid to private ownership.

The present average rate of royalty on anthracite is probably between 32 and 35 cents a ton on all sizes, which is from 12 to 14 per cent of the selling value at the mine. The minimum rate (about 10 per cent) is found in some old leases, and the maximum (20 to 27 per cent) in leases made in the last five years. R. V. Norris states that in the late sixties, when the annual output of anthracite was around 15,000,000 tons, royalties were 8 to 10 cents a ton on prepared sizes, but that no charge was made on the smaller sizes. In the seventies the rate rose to 25 cents on prepared, one-half that on pea, and one-fourth on smaller sizes. By the middle eighties, when the output was a third what it is now, the rate was about double that of the seventies—that is, 40 to 50 cents on the larger sizes and 5 to 10 cents on the smaller sizes. The tendency is still upward by reason of increases in the rates for intermediate sizes, and the operation of royalty rates, based on a percentage of the selling value, an increasing quantity. Figured on the output from the Girard lands, which is

nearly 3 per cent of the total production, the gross return to the estate from its coal lands is over 50 cents a ton.

Nor is the increase in value of anthracite lands any less striking. At the beginning of the last century, as stated by Mr. Norris, the great bulk of these lands were patented by the State of Pennsylvania for 2 dols. to 4 dols. an acre; in the middle of the century the price of the best land rose to 50 dols., and in 1875 even to 500 dols. Now 3000 dols. an acre has been paid for virgin coal land, and little is on the market at that. In considering these increases in land values the effect of interest and taxes must not be overlooked.

The bituminous coal industry is a modern institution compared with the mining of anthracite, and much of the bituminous coal land was acquired by the operating companies during the last twenty years for little if anything more than its surface value. To-day there are large areas of bituminous coal-bearing lands that because they are undeveloped and without railroads can be purchased at a low price, but little or no anthracite land is on the market, and little has changed hands for years. The present average resource cost of bituminous coal is not much over 5 cents a ton, or about 4 per cent of the average selling value at the mine. In the Pocahontas region and the Pittsburgh district the royalties are much higher, but these, like others that might be cited, are exceptions—one due to coal of special quality, and the other to location—factors which, incidentally, are exactly those that have assisted in making the resource cost of anthracite what it is.

Should you be interested in summing up all these various costs and striking a balance between labour's share and capital's return you would find that the mine worker, the trainman, and the wagon driver together receive fully half of the price of the anthracite delivered at your house, and the same three classes of labour receive not less than half the price paid by the average consumer for the cheaper soft coal. In a similar manner the average return on the capital invested in land, mining plant, railroads, and coal yard may be roughly calculated, with the result that landlord, bondholder, and stockholder of coal company and railroad together receive about 1.15 dols. from the ton of anthracite, and only 50 to 75 cents from the ton of bituminous coal, and of either of these amounts the mine operator's share is only a small fraction.

It is not the purpose of this analysis of costs to offer any cure-all for the high price of coal, yet some comment on the facts presented may possess value. At least certain lines of approach can be pointed out as not very promising. For example, anyone who is at all cognisant of the trend in price of labour and material can see little hope of relief in lower costs for these items. Furthermore, observation of the advances made in mining methods in the last decade or two affords slight warrant for belief in any charge of wasteful operation. As consumers of coal we might do well to imitate the economy now enforced by the producers in their engineering practice. In the Northern Anthracite field machine mining is extracting coal from 22 and 24-inch beds, and throughout the anthracite region the average recovery of coal in mining is 65 per cent as against 40 per cent only twenty years ago. Nor are the bituminous operators any less progressive in their conservation of the coal they mine.

Yet it must be remembered that conservation of a natural resource, though it will undoubtedly be of direct economic benefit in the future, is not essentially a cheapening process; in fact, these increased recoveries of coal have in large part become possible only because of a higher market price. And, following further this line of thought, we may say that the increased safety in the coal mines that has come through the combined efforts of the coal companies, the State inspectors, and the Federal Bureau of Mines necessarily involves some increase in cost of operation, but the few cents per ton thus added to the cost is a small price to pay for the satisfaction of having the stain of blood removed from the coal we buy.

In the item of transportation perhaps the most promising means of relief is that of reducing the length of haul. Though many a consumer's preference for coal from a distant field over that from a field nearer home is based on special requirements, the deciding element in the preference of other consumers is simply the price, and this in turn may be largely due to a differential freight scale, which is thus not in the public interest if we admit the premise that it is wasteful to burn coal in hauling coal into coal districts or past such districts, except in so far as quality requirements absolutely demand the long-haul coal.

Reduction in marketing costs is a reform so close to the consumer that he should be able to find for himself whatever relief is possible. Prof. Mead, of the University of Pennsylvania, is authority for the statement that the delivery of coal is costing the dealers 50 cents a ton more than is necessary.

There only remains, therefore, the first item of all—the value of the coal in the ground, or rather the return which the land-owner is asking for this natural resource. The fortunate holder of coal land, whether a very human individual or a soulless corporation, or a large trust estate administered for benevolence only, is likely to endeavour to get all that the traffic will bear. Especially in the possession of a limited resource like anthracite the tendency has been and will continue to be to increase royalties as the years pass, and the only penalty imposed by the State for high royalties seems to be high taxes, which too often, indeed, serve to justify the high resource cost put upon coal in the ground. Finally, in considering royalty rates or depletion charge we must not overlook the interest that accumulates throughout the period between the purchase of the coal land and the removal of the last ton of coal.

In placing a value upon the Choctaw lands some years ago the Geological Survey figured the aggregate royalties at current rates as 160 million dollars, but if that amount of royalty were to be collected through the six or seven centuries required for mining the two thousand million tons under this land the present value of the land would be only 6½ million dollars if purchased by the Federal Government, or only 4 millions if purchased by the State of Oklahoma, and even less if the project were financed by a corporation that would need to issue 6 per cent bonds. Such is an illustration from actual experience in coal-land valuation—the four to six million dollars invested in these Oklahoma coal lands now would require a final return of 160 million dollars in royalties to balance the account.

More recently Mr. Cushing, the editor of *Black Diamond*, has figured the cost of a monopolistic control of the available coal resources east of the Rocky Mountains on the basis of the United States Geological Survey estimate of two million million tons. At a valuation of coal in the ground of only 1 cent a ton, which, as he stated, is less than has been paid for large holdings, this deal would require a capitalisation of 20 billion dollars, and the fixed charges on the bonds of this United States Coal Corporation would require an interest charge alone of 2 dols. a ton against a production of 600 million tons a year. Mr. Cushing characterises such a financial undertaking in mild terms as hopelessly impossible, and yet his figures, which do not include taxes, are most enlightening as affording some measure of the cost of possessing an undeveloped resource. Incidentally, these startling figures furnish a strong argument for the present policy of the National Government in retaining ownership of the public coal lands, at least up to the time when the market conditions justify the opening of a mine, and then either leasing or selling a tract only large enough for that operation. The consumer of the next century simply can not afford to have private capitalists invest to-day in coal land for their great grandchilden to lease.

The burden that seems evitable under unregulated private ownership of a natural resource like coal is that because the lands containing these national reserves of heat and power are taxed and because the individual or corporation properly charges up interest at current rates

on his large holding, the consumer must pay a resource cost which takes into account the long period of undevelopment. Even the high rates of royalty on the lands of the Girard estate may be found less excessive than they seem if a century's taxes and interest charges are figured. Yet the fact remains that the royalty for anthracite represents a much larger proportion of the cost of the mined coal than any bituminous royalties. Moreover, we believe the highest royalty prevailing in the anthracite region has far more influence in fixing the selling price than the lower rates of the older leases.

Any study of costs in the coal industry finds its point in the question, not who but what fixes the price of coal. The cost of mining coal, like the cost of living, is increasing. Exact mining costs, however, can not be determined until the operators have accomplished their reform of standardising accounting. Too often the operator includes in his account only the two largest and most obvious items, labour and material. Thus when the market for bituminous coal is dull, the company whose land cost little or nothing is able to set a lower limit of price than the company whose coal must stand a charge of 5 to 10 cents per ton, or even more, be that charge called royalty, depletion, or amortisation. At such times the operator with the larger resource cost must sell at a real though not always recognised loss, but of course with the hope of recouping himself at times of high prices like the present, if fortunately he has any coal to sell not already contracted for.

Even with the average low resource cost of bituminous coal the state of competition that is tied up with idle and half-worked mines results in an average total cost that is little below the average selling price. Of course in this business there are those, both large operators and small, who make a profit in lean as well as in fat years, just as there are those for whom the prosperous years are too infrequent to keep them out of the hands of receivers.

In the anthracite fields the mining costs, and especially the resource costs, are higher. But here, with an average market demand that normally exceeds or at least equals the available supply (and with the passing years this disparity must be expected to increase), there results naturally a lack of competition for the market. Even gentlemen's agreements are unnecessary as long as every operator can reasonably expect to sell his product, and the market price of anthracite at the mine must therefore tend to be fixed by the operator who has the largest mine and resource cost, rather than by his neighbour who may be doubly favoured with a mine less expensive to work and a lease less exacting in terms.

Confessedly, this analysis of the cost elements that enter into the price of coal emphasises our lack of specific facts, which can be supplied in the future only through "installation of uniform cost-keeping methods and uniform and improved accounting systems," to quote from the declaration of purposes of the Pittsburgh coal producers. With the results of such book-keeping in hand more definite reply can be made to the public's appeal for relief from high prices. Yet even now it may be possible to suggest how that relief will eventually be obtained. Study of present conditions in the coal mining districts fails to encourage the idea of governmental operation of the seven thousand coal mines in this country. More in line with the trend of public sentiment in the last decade, however, is governmental control in the interest of the consumer by regulation of prices.

Competition seems to have failed of late years to benefit the consumer of coal. In the bituminous fields the competition whenever present has been wasteful, and in the anthracite fields there has been practical absence of healthy competition, and whether too great or too little competition, the result is the same—to increase the actual cost of bituminous coal by saddling the industry and its product with the fixed charges on idle or semi-idle mines, and to raise the price of anthracite coal by favouring the

In estimating the aggregate losses incurred by society by reason of the large number of mines not working at full capacity, the facts to be considered are that the capital invested in mine equipment asks a wage based on a year of 365 days of 24 hours, while labour's year averaged last year only 230 days in the anthracite mines and only 203 days in the bituminous mines, with only five to eight hours to the day.

As coal is more an inter-state than intra-state commodity, any regulation of prices needs to be under Federal control, and to benefit both consumer and producer such control can not stop with transportation and mining costs, but must stand ready to exercise full rights as a trustee of the people over the coal in the ground. The private owner of coal land, which derives its real value from society's needs, has no more sacred right to decide whether or not that coal shall be mined when it is needed by society or to fix an exorbitant price on this indispensable national resource than the coal operators have to combine for the purpose of exacting an excessive profit from the consumer, or the railroads to charge all that the traffic may bear. The proposal to bring land-owner under the same rule as mine operator and coal carrier may seem radical, but where is the point at which coal becomes the resource upon which industrial society depends for its very life?

THE COLLEGE OF TECHNOLOGY.

IN the academic world the word "school" carries two distinct meanings. It embraces on the one hand institutions like the Manchester Grammar School, Harrow School, a Sunday School, or an Elementary School—all of them concerned with some aspect of primary or secondary education. It further embraces such things as the Oxford Final Schools—*literæ humaniores*, modern languages and the like—the Cambridge School of Agriculture, the London School of Economics, in all of which the work done is of an advanced kind, and often (barring the Oxford schools) concerned more with research and post-graduate study than even with university work at the undergraduate stage. The academic person knows this, and likes the word "school," which by right embraces all education. But most people are not academic. To them the word "school" brings visions of small boys in knickerbockers and small girls with pigtails. They consequently misconceive the work of the *School* of Technology. To remove the cause of their misconception the Governing Body has decided to change the name from "School" to "College."

Official Recognition of the University Status of the School of Technology.—This change of name has been rendered the more necessary by the development of the School of Technology during recent years. In 1911-12 the College was first recognised by the Board of Education as being of university rank, and was placed under its own name in the list of British universities and university colleges receiving grants from the Government.

Number and Status of Students.—In the two years before the War the number of matriculated students in the College increased by 50 per cent, and though the War has drawn away over two-thirds of its students to-day there are actually more undergraduates than there were in 1911-12. At that time only 30 per cent of those entering the College for a full course had matriculated. Now the proportion has reached 75 per cent; and it cannot go much higher, for English education must remain democratic, and it must always be possible for able young men engaged in industry to enter a Faculty of Technology without first having to pass a schoolboy matriculation examination. On the other hand, boys who are attending higher secondary schools will generally do well to remain at school for one or two years after reaching matriculation standard before entering the College. The number who

do so has rapidly increased of late years. Indeed, the average student now enters the School of Technology having done between one and two more years' work at school than was the case in 1911-12.

The proportion of evening students doing the most advanced work meanwhile doubled itself between 1913 and 1916; and even to-day, after two years of the Military Service Acts, the proportion is 60 per cent greater than it was in 1911-12.

Staff.—During the same six years the following among other appointments have brought distinction to the College:—Prof. G. G. Stoney, F.R.S.; Prof. A. G. Green, F.R.S.; Prof. Miles Walker, M.I.E.E.; E. M. Wrong (Fellow of Magdalen College, Oxford); S. Lees (formerly Fellow of St. John's College, Cambridge); F. M. Rowe (formerly Research Fellow of Leeds University).

Salaries.—With a view to enabling the College to attract and retain experts of first-rate ability, whose services are in great demand by industrial concerns, the Governing Body is now offering professorial salaries up to £1000 or £1200 a year, with permission to undertake private consulting work under suitable conditions.

Increase in Government Grants.—The increase in expenditure has been partly met by larger Government grants. In the year 1910-11 the grant received amounted to £11,895, while that received during 1915-16 was £16,646, including a special War grant of £1250.

Expenditure.—According to Blue Book figures the annual expenditure of the College is now about equal to that of the University of Sheffield, and is half as big again as that of the University of Bristol.

New Buildings.—Before the War the City Council had agreed to extend the College buildings to the east, between Whitworth Street and Granby Row, and in the new building to provide internal combustion engine laboratories, with aeronautical and motor-car sections, a new foundry, and a boiler-house, the total cost to be about £20,000. Engineering firms in the neighbourhood had shown their interest in the work of the College by promising equipment for the new buildings to the value of about £3000.

Educational Reforms.—Changes have been made in the University curriculum, and the final examination has been brought into line with Honours schools in most British universities.

Research.—But perhaps the greatest change of all is in the quantity of the research work undertaken. This result is in part due to the fact that the Governing Body now offers annually several Research Scholarships, each of the value of £100 a year. Moreover, lecturers are appointed not only to teach but to research; they understand their advancement largely depends upon their research. In the summer of 1916 five new research rooms were equipped, and in one was housed the new Sub-Department of Dyestuffs Research, set up wholly for experimental and post-graduate work. The greater part of the research at present in progress is directly concerned with the War. A confidential report on the war activities of the College was recently prepared at the request of the War Office, who, when acknowledging its receipt, said that they found it to be "of extreme value." It is, of course, impossible to publish this report at the present time.

Co-operation of Industrial and Commercial Concerns with the School of Technology.—Co-operation between the College and the industries of the district is essential if both are to achieve their best. Such co-operation exists and is increasing. Graduates of the College have no difficulty in finding employment; indeed, for many years past the demand has been far greater than the supply. Co-operative researches in which the practical experience of individual manufacturers is combined with the wider but less specialised knowledge of members of the College are increasing in number. The City Council has recently approved conditions under which it is hoped that the number of these co-operative researches will continue to grow.

Such in recent years has been the growth of the School of Technology, founded in 1824 as the Manchester Mechanics' Institution, and now a College of university rank, attracting students from all parts of the world.

HISTORY OF THE NICKEL INDUSTRY SINCE 1910.*

By E. P. MATHEWSON, B.Sc.

The history of the nickel industry in Canada and the United States was the subject of a most interesting address by the late D. H. Browne, before this section of the Society in January, 1911 (see *Journ. Soc. Chem. Ind.*, 1911, p. 248). This paper is intended to fill the gap between that date and the present in the history of the nickel industry.

In the first place, the use of nickel has increased immensely during the past seven years, and the great war has emphasised its importance to a very large extent. Some of the greatest engineering structures of the world have been recently completed, and but for the use of nickel as an alloy in the steel employed, their construction would have been entirely out of the question. One of the most recent of these structures is the new Quebec Bridge.

The lack of nickel in Germany after the first few months of the war caused our enemies to offer great inducements to producers to supply them with nickel. They were successful in securing a supply from Norway, which, however, by means of certain negotiations on the part of the British Government, was cut off almost entirely, and in May of 1917, the refinery at Kristiansands was damaged by fire to such an extent that no nickel has been produced at that plant since that time.

The affair of the *Deutschland* is familiar to all and caused a feeling of uneasiness amongst the Allies at the time.

It is no secret to state that the nickel producers, particularly the International Nickel Company, of which the Canadian Copper Company is the chief subsidiary, became much alarmed at what they considered a lack of market for nickel proportionate to their producing capacities.

Just before the war broke out, the manufacturers of structural steel seemed suddenly to become aware of the value of nickel steel and its use was increasing rapidly. When the war broke out, the demand for nickel in the war industries absorbed the entire supply, and it is generally believed that after the war the demand for nickel will continue to a still greater extent.

In connection with the automobile industry, the consumption of nickel is quite large and growing constantly. For making of shafting, particularly marine shafting, nickel seems to be essential; but the great consumption of the metal will be in the form of nickel steel alloy for structural purposes.

Within the past few years, the enormous reserves in the lower levels of the Creighton Mine have been discovered, and at present a very important investigation is being made by the Mond Nickel Company on the lot west of the Creighton Mine, where diamond drilling is being undertaken with the object of striking the Creighton ore body extension at a depth of 3800 feet. This is twice the depth of any of the workings in the nickel region of Canada. Some very interesting diamond drilling has been undertaken in the Eastern part of the Sudbury district by the Longyear Company, they having drilled through 100 feet of wash and found nickel ores at some distance below the wash.

Among interesting changes in smelting are the following: The Mond Nickel Company has moved to a point eight miles east of Sudbury on the Canadian Pacific Railway and constructed a modern smelter and model town called Coniston.

* Abstract of a Paper read before the Canadian Section of the Society of Chemical Industry, Toronto, December 21, 1917.

The old Murray Mine is now the principal holding of the British America Nickel Corporation, Ltd., which is the successor of several of the older companies. The depression in financial circles at the beginning of the war had its effect on the nickel industry and particularly on this company, and work was suspended. But later, as the company owned the Hybinette patents for refining nickel, which are considered very valuable and which had been in operation for a number of years at the Kristiansands refinery, Norway, it was decided to resume the construction of the plant at Nickelton, and this work is now well under way.

Some time ago nickel became a political issue in Canada, but with the entry of the United States into the war on the side of the Allies, this ceased to interest politicians. However, one good result of the nickel agitation was the appointment of the Royal Ontario Nickel Commission, which recently completed its labours and published a voluminous report which is generally considered to be the finest thing of the kind ever offered to the public (see *Journ. Soc. Chem. Ind.*, 1917, p. 490).

Since the report of the Commission has been made public, the rate of taxation on nickel properties has been materially increased, with a corresponding increase in revenue to the Government, which more than justified the expense of the Commission.

The importance of Canada as a nickel producer has been maintained through all these years, and it now is apparent that the country will soon become equally important in the refining of nickel.

The International Nickel Company has under construction, and near completion, a modern refinery at Port Colborne, Ontario, which will have an initial capacity of 7500 tons of nickel per annum, and provision has been made for enlargement to double that capacity.

The British America Nickel Corporation's plant will be nearly the same size as the Port Colborne plant, but will utilise the Hybinette electrolytic process, which is quite distinct from that used by the International Nickel Company, and in it also will be made provision for enlargement as the needs of the industry demand. This plant, however, will not be completed until the year 1919.—*Journal of the Society of Chemical Industry*, xxxvii., No. 4.

ORDERS OF THE MINISTRY OF MUNITIONS.

SHELLAC.

THE Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm Regulations and all other powers thereunto enabling him, hereby orders as follows:—

1. Every person holding or having under his control, whether in stock or transit, any Shellac as hereinafter defined, shall within seven days of the date hereof furnish a return to the Controller, Non-Ferrous Materials Supply M.S./L., at the address undermentioned, containing full particulars of such Shellac, the respective grades thereof, the purposes for which the same is intended, and the average monthly consumption of Shellac by such person for any purpose during the year 1917; provided that no such return is required from any person unless he has at some time since January 1, 1917, had in his possession or under his control an amount of Shellac exceeding an aggregate of 7½ cwts. net weight.

2. No person shall as from the date hereof until further notice purchase or, except for the purpose of carrying out a contract in writing existing prior to such date for the purchase of Shellac, take delivery of any Shellac whether situate in or outside the United Kingdom, except under and in accordance with the terms of a license issued under the authority of the Minister of Munitions, or sell, or except for the purpose of carrying out a contract in writing for the sale of Shellac existing at the date thereof, deliver any such Shellac to any person other than the holder of such a license and in accordance with the terms thereof, provided that no such license shall be required by any person for the purchase of Shellac in quantities not exceeding an aggregate of 7½ cwts. net weight during any one calendar month or for the sale or delivery of such maximum quantity on any such purchase.

3. The expression "Shellac" shall for the purpose of this Order mean:—

Shellac,
Seed Lac,
Stick Lac,
Garnet Lac,
and Button Lac,

or any of them.

4. This Order may be cited as "The Shellac Control Order, 1918."

5. All applications for licenses shall be addressed to—The Controller, Non-Ferrous Materials Supply, M.S./L., Ministry of Munitions, 8, Northumberland Avenue, London, W.C. 2.

BISMUTH ORES, BISMUTH METAL, AND PRODUCTS THEREFROM.

1. In exercise of the powers conferred upon him by Regulation 30A of the Defence of the Realm Regulations the Minister of Munitions hereby orders that the war material to which that Regulation applies shall include war material of the following classes and descriptions, namely:—

All Bismuth-bearing ores and Bismuth metal and alloys and salts derived or produced therefrom.

2. In exercise of the powers conferred on him by the Defence of the Realm Regulations and all other powers thereunto enabling him, the Minister of Munitions hereby orders as follows:—

(1). Every person holding any stock of any of the materials specified in Clause 1 of this Order shall within fourteen days from the date hereof furnish full particulars of any such stock to the Controller of Non-Ferrous Materials Supply, Ministry of Munitions, 8, Northumberland Avenue, London, W.C. 2 (hereinafter referred to as the Controller).

(2). Every owner, lessee, or licensee of a mine or mines producing Bismuth-bearing ores situate in the United Kingdom shall, within fourteen days from the date hereof and once in every month thereafter, make to the Controller, on and in accordance with the form prescribed by the Controller, a return showing particulars of his monthly output and deliveries of Bismuth ore, concentrates, and stocks on hand at the of each month.

(3). Every merchant, importer, or broker who receives consignments from outside the United Kingdom of Bismuth ores shall, within fourteen days from the date hereof and once in every month thereafter, make to the Controller on and in accordance with the form prescribed by the Controller, a return showing all shipments afloat and all parcels landed or in warehouse during the month preceding the day of the return.

(4). Every person who treats any ore to which this Order applies or manufactures any material or article therefrom shall, within fourteen days from the date hereof and once in every month thereafter, make to the Controller on and in accordance with the form prescribed by the Controller, a return showing stock in hand, receipts, and consumption of such ore and stock in hand, output, and deliveries of manufactures from such ore.

(5). Every person who in any manufacture uses Bismuth metal or any alloy thereof shall, on the 1st day of April, 1918, and thereafter on the first day of every calendar month, make to the Controller a return on and in accordance with the form prescribed by the Controller, showing the quantity of Bismuth metal or any alloy thereof received by him from the producer, the quantity consumed by him in such manufacture during the preceding month, and the stock in hand at the end of the said month.

(6). Notwithstanding the above, no return is required from any person whose total stock in hand and not intended to be used in connection with the manufacture or alloy of steel or other metal has not during the period for which a return would but for this exception have been required exceeded in the case of—

Bismuth salts	56 lbs.
Bismuth metal or alloy thereof ..	14 lbs.

3. Every return made by any person for the purpose of this Order shall be signed by such person, or, if the return is made on behalf of a firm or company, shall be signed by a partner, director, manager, or other responsible official, and every statement contained therein shall be true and accurate.

4. Applications for permits under this Order should be made to the Controller of Non-Ferrous Materials Supply, M.S./P., Ministry of Munitions, 8, Northumberland Avenue, W.C. 2.

5. This Order may be cited as the Bismuth Order, 1918.

General Permit under the Above Order.

The Minister of Munitions gives notice that he hereby until further notice permits any person to purchase Bismuth metal and Bismuth salts not exceeding in any one calendar month in the case of Bismuth metal a total quantity of 10 lbs. and in the case of Bismuth salts a total quantity of 56 lbs., provided that the same are purchased and in fact used for pharmaceutical or medical purposes only, and further permits a sale to any person purchasing as hereinbefore authorised.

March 12, 1918.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, February 28, 1918.

Sir J. J. Thomson, O.M., President, in the Chair.

Papers were read as follows:—

"*Scattering of Light by Dust free Air, with Artificial Reproduction of the Blue Sky.*" (Preliminary Note). By Hon. R. J. Strutt, F.R.S.

1. By proper arrangement of the experimental conditions, it is possible to observe the scattering of light by pure air, free of dust, in a small scale laboratory experiment.

2. Similar results can be obtained with other gases. Hydrogen gives much less scattering than air, oxygen about the same, carbon dioxide decidedly more.

3. The scattered light in air and in all the other gases is blue—the blue of the sky—illustrating very directly the theory that attributes the blue of the sky to scattering by the molecules of air. Tyndall obtained the blue by means of fine-grained fogs, precipitated from organic vapours. This was a valuable contribution, but his fogs were, of course, both chemically and physically very different from dust-free air.

4. The scattered light is almost completely polarised.

"*The Lommel-Weber Ω Function and its Application to the Problem of Electric Waves on a Thin Anchor Ring.*" By J. R. Airey, D.Sc.

This paper contains a short summary of the properties of the $\Omega_n(x)$ function defined by the integral—

$$\frac{1}{\pi}\int_0^\pi \sin(x\sin\theta - n\theta)d\theta.$$

References are given to the applications of $\Omega_0(x)$, $\Omega_1(x)$, $\Omega_{n+1}(n)$, and $\Omega_{n-1}(n)$ to a number of physical problems, especially that of the electrical vibrations on a thin anchor ring. It is shown that the real part of $(a^2\kappa^2 - m^2)L$ can be written in the form—

$$\frac{m^2\pi}{2}\Big[\Omega_{2m-1}(2m) - \Omega_{2m+1}(2m)\Big]$$

and the wave-lengths of the vibrations λ_m can be formed from the formula—

$$\frac{2\pi a}{m}\Big\{1 - \frac{\pi}{4L}\Big[\Omega_{2m-1}(2m) - \Omega_{2m+1}(2m)\Big]\Big\}$$

where $L = \log\frac{8a}{\epsilon}$, a the radius of the anchor ring, ϵ the radius of its cross section, m a positive integer, and $\lambda_m = \frac{2\pi}{\kappa}$.

Methods of calculating $\Omega_n(n)$ and $\Omega_{n-1}(n)$ are given, depending upon the Schläfli polynomials $S_n(n)$ and $S_{n-1}(n)$, and the Neumann functions $G_n(n)$ and $G_{n-1}(n)$, which have been tabulated for a large number of values of n. Finally, the asymptotic expansion of $\Omega_n(x)$ where x is nearly equal to n, is derived from the integral defining the function by a method similar to the Saddle-point method.

"*Investigations on Textile Fibres.*" By W. Harrison.

1. Dry fibres when subjected to stress, exhibit a kind of plasticity in which the strains produced remain when the stress is removed, but are accompanied by corresponding internal stresses.

2. Fibres deformed in the above manner return to their original shape when placed in cold water.

3. Fibres in contact with cold water are elastic; strains produced by the application of stress disappear when the stress is removed, more quickly with some fibres than with others.

4. In boiling water fibres are plastic, the application of stress produces *permanent deformation* with *no corresponding* internal stresses in the case of wool and only slight stresses with other fibres.

5. The double refraction exhibited by the natural fibres is due to the presence of internal stresses.

6. The swelling produced by treatment of cotton fibres with solutions of sodium hydrate and of wool fibres with sulphuric acid is due to the internal stresses naturally present in these fibres.

7. The internal stresses present in natural fibres appear to originate in the moulding of the fibres during growth and in their subsequent drying, and can be imitated experimentally with artificial fibres.

"*Critical Loading of Struts and Structures.*" By W. L. Cowley and H. Levy.

This paper is concerned with the elastic stability of structures composed of members under compression, and treats problems relating to the strength of such a construction as a beam under end thrusts and supported at intermediate points.

For introducing the method of analysis, the discussion is first directed to the case of a prismatic, homogeneous, uniform strut with simple supports, and loaded longitudinally, laterally, and by externally applied couples at the ends. A critical loading is associated with the production of bending moments and deflections, large in comparison with those allowable by the assumptions upon which the analysis is based. In this case the criticals occur when the end thrusts attain Euler's values, unless a certain relation exists between the bending moments at the ends and the lateral loading. For longitudinal loads greater than the lowest critical, the equilibrium is assumed unstable to small disturbances in the light of stability investigations for Euler's simple strut.

The analysis is afterwards extended to the case of a continuous beam under lateral and longitudinal loads, the intermediate supports undergoing deflections. This introduces an extension of Clapeyron's theorem or the equation of three moments, in a simple form, suitable for

rapid solution when both the lateral and the longitudinal loadings are known.

The investigation shows that failure does not necessarily occur when one of the bays is of Euler's lowest critical length. In this instance, however, the two equations of three moments involving this bay take an indeterminate form and must be replaced by two other equations which can easily be derived. The structure will not fail, in general, through the bending moments becoming excessive, even if several of the bays are of Euler's critical length, provided at least one bay is not of that length.

CHEMICAL SOCIETY.

Ordinary Meeting, February 21, 1918.

Prof. W. J. POPE, C.B.E., F.R.S., President, in the Chair.

MESSRS. R. I. Phipps and A. S. Carlos were formally admitted Fellows of the Society.

Certificates for election were read for the first time in favour of Albert Henry Clark, B.Sc., 701, S. Wood Street, Chicago, U.S.A.; Horace George Evans, B.A., B.Sc., 393, City Road, Edgbaston, Birmingham; Charles Eddie Gallagher, The Vestry House, St. Magnus-the-Martyr, Lower Thames Street, E.C. 3; Nathaniel Makover, B.Sc., 13, Bancroft Road, E. 1; Alexander Lyle Thomson, 11, Beresford Gardens, Trinity, Edinburgh; Herbert John Watson, 64, Peel House Lane, Widnes.

A certificate for election has been authorised by the Council for presentation to ballot under By-law I. (3) in favour of Stanley Warburton, Titaghur Paper Mills Co., Ltd., Titagbur, India.

It was reported that Mr. Thomas Tyrer, who was elected a Fellow in 1876, died on February 21, 1918.

The PRESIDENT announced that the following changes in the Officers and Council were proposed by the Council:—

Vice-Presidents to retire—Prof. F. R. Japp and Sir Richard Threlfall.

Ordinary Members of Council to retire—Rt. Hon. the Earl of Berkeley, Prof. H. C. H. Carpenter, Dr. R. H. Aders Plimmer, and Prof. J. F. Thorpe.

President—Prof. William Jackson Pope.

Vice-Presidents who have filled the office of President—Prof. H. E Armstrong, Prof. A. Crum Brown, Sir William Crookes, Sir James Dewar, Prof. Harold B. Dixon, Prof. Percy F. Frankland, Dr. A. G. Vernon Harcourt, Prof. W. Odling, Prof. W. H. Perkin, Prof. J. Emerson Reynolds, Dr. Alexander Scott, Sir Edward Thorpe, and Sir William A. Tilden.

Treasurer—Dr. M. O. Forster.

Honorary Secretaries—Dr. Samuel Smiles and Prof. J. C. Philip.

Foreign Secretary—Lt.-Col. Arthur W. Crossley.

Vice-Presidents—Prof. F. G. Donnan, Prof. G. G. Henderson, Prof. A. Lapworth, Lt.-Col. A. Smithells, Prof. W. P. Wynne, and Prof. S. Young.

New Ordinary Members of Council—Mr. J. L. Baker, Prof. J. C. Irvine, Sir Herbert Jackson, and Mr. E. W. Voelcker.

Mr. C. F. Cross, Dr. C. A. Keane, and Dr. E. W. Voelcker were elected Auditors to audit the Society's Accounts.

Messrs. R. E. Jackson and P. T. White were elected Scrutators, and a ballot for the election of Fellows was held. The following were subsequently declared elected as Fellows:—Ernest Atkinson; Charles Frederick Lee Barber; Albert Leslie Bloomfield, B.A.: John Boothman; Joseph William Christelow, B.Sc.; Edgar Alfred Coakill; Ransome Wallace Cooper; Thomas Crowdy; Harry Dugald Keith Drew, B.Sc.; John Clare Newlands Eastick; Frederick William Edwards; Thomas Gifford Elliot; Frederick William Emerson; Frederick Page Evans, B.Sc.; *Charles Henry Fielding; Robert Fleming, B.A.*; Thomas Frazer, B.A.; Frederic Horace Garner, M.Sc.; Cecil Stevenson Garnett; Julius Geidard; William Frank Grant, B.Sc.; William Robinson Grist; Francis Clint Guthrie, B.A.; Joseph Eli Hanson; Ernest Hardiker; Alan Haythornthwaite, B.Sc.; Thomas John Hitchcock; Harold Housley, M.Sc.; Owen Rhys Howell, B.Sc.; William Earl Hughes; Herbert Spencer Kipling; Thomas Williamson Kirkwood, B.Sc; Kumudchandra Ghelabhai Laiwala, M.A., B.Sc.; Harold Lawrence; Francis Charles Lewis, B.Sc.; Arnold Bradley Lowndes; William Jackson Lund, M.Sc.Tech.; Archibald Bruce Macallum; Alfred Bertram Mann; Elias Mendoza; John Richard Morgan, B.Sc.; Arthur Macdonald Munro, M.A.; Theketh Kumaran Nair, B.A., B.Sc.; Robert Atkinson Oddy; Horace Finningley Oxley, B.A.; Henri Marc Pezzani; David John Prichard Phillips, B.Sc.; Tudor Williams Price, B.A., M.Sc.; Robert Ray, B.Sc.; Ferdinand Roques; Alfred Ulrich Max Schlaepfer, D.Sc.Tech.; William Leonard Scotcher; Harold Pethick Shilston; Snow Blagburn Tallantyre, B.Sc.; George Taylor; John Cameron Clarke Taylor; Hugh Arwel Thomas, B.Sc.; Albert Edward Timmins; John Trotter, M.A., D.Sc.; George Johnston Twine; Leonard Ellerton Vlies; Glen Raymond Wakeham, B.Sc.; Godfrey Warburton; Harry Wignall, M.Sc.; Arthur William Willis; Charles Edmund Wood, M.Sc.

Prof the Hon. R. J. STRUTT, F.R.S., then delivered his lecture, entitled "Recent Studies on Active Nitrogen." A vote of thanks proposed by Dr. A. SCOTT, seconded by Prof. FINDLAY, and supported by the PRESIDENT, was carried with acclamation.

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS.

Ordinary Meeting, March 6, 1918.

Dr. S. RIDEAL, President, in the Chair.

CERTIFICATES *were read for the first time in favour of* Messrs. Stanley Dixon, A.I.C., John Frederick Briggs, A.C.G.I., Robert Duncan Masson, F.I.C., and John William Hinchley, A.R.S.M.

A certificate was read for the second time in favour of Mr. William Herbert Miles.

Mr. Tom M. McKenzie was elected a member of the Society.

The following papers were read:—

"*On a Case of Poisoning by Potatoes.*" By F. W. HARRIS, F.I.C., and T. COCKBURN, F.I.C.

"*The Graduation and Calibration of Gerber New Milk Butyrometers.*" By F. D. DAY, B.Sc., F.I.C., and MICHAEL GRIMES.

The authors have carefully determined the conditions under which the Gerber test should be carried out, particularly as regards the calibration of the butyrometers, and have redetermined the volume of the scale divisions. They have also examined the fat obtained in the Gerber test, and have compared its properties with those of unchanged milk fat in order to determine whether the accepted coefficient of expansion and density for milk fat will hold good in the case of the fat of the Gerber test. They consider the Gerber method to give very accurate results.

"*The Determination of Potash.*" By BERTRAM BLOUNT, F.I.C.

The author has considered the question of the determination of potash which has lately been a matter of public interest, especially in connection with the provision of this substance for national purposes. He has drawn up a

statement of what, in his experience, appears to be the most accurate and satisfactory method.

The method is generally applicable for the determination of the total quantity of potash in all ordinary materials, and if properly worked may be regarded as reliable.

NATIONAL ASSOCIATION OF INDUSTRIAL CHEMISTS.

On Saturday, March 9, 1918, the Council of the National Association of Industrial Chemists met in conference in Birmingham, at the rooms of the Chamber of Commerce, and in the evening there took place an open meeting of chemists and metallurgists at the Birmingham and Midland Institute. The conference, which was private, was presided over by Mr. A. C. J. Charlier (London), President. Delegates were present from various parts of the country. Matters of organisation and policy were dealt with, and an Executive was appointed as follows:—Messrs. Hargest (Newcastle), Thomas (Scunthorpe), Blackwell (Birmingham), Harrap (London), Davison (Middlesbro'), and Russell (Sheffield).

Mr. E. H. Newton (Wednesbury), presided at the meeting at the Midland Institute, which was well attended.

Mr. E. J. Thackeray (Sheffield), National Secretary, stated that the reports received showed that good progress was being made by the Association. Sections had been formed at London, Birmingham, Sheffield, Middlesbro', Newcastle, and Scunthorpe, and the membership was constantly growing. The aim was, by collective action, to advance the economic and social position of industrial chemists and metallurgists.

Mr. Charlier, the President, stated that the National Council now possessed six sections with their own local councils. The latter, while controlled by the Executive, had authority to cater for the needs of chemists within their own districts. The Association was out for improved status and financial recognition for the average works chemist—the man who handled big quantities of material. It did not follow that the academic man necessarily made the best works chemist. They were of opinion that in three or four years a thorough knowledge of organic or inorganic chemistry could be acquired, after which a man should specialise in his own particular branch of his profession. The Association wanted to see the door between the works and the laboratory opened much wider than in the past. Therefore they desired to see the younger members of the profession take up a short course of engineering. It would be of great service to the chemist who aspired to become a works manager. The Association desired to stop night work if the effect was to interfere with the studies either at night or in the day of young men in the laboratories. Laboratory practice and technical training in the schools and colleges needed to go together. The present system of training was often faulty and inadequate. It did not provide sufficient scope, and sometimes the work on simple analyses was so continuous that "blind-alley occupation" ensued. That sort of thing must be stopped. Their Executive failed to see that the newly formed British Association of Chemists could achieve what the National Association could. The objects of the two bodies were different. They also felt that the Sheffield Metallurgical and Chemical Association could not assist them, because its idea of "qualification" was wholly impracticable from the point of view of an industrial association. The Sheffield body consisted mostly of senior members, and the qualification test was unsuited to student members or to young chemists in any laboratory. The aim of the National was to draw into its fold all junior works chemists. The academic and research man of grammes and test-tubes was properly provided for. It had been suggested that the National Association was simply a trades union; it was not established with the intention of acting on trade union lines. The spirit of the Association was democratic, but its methods were not of the trade union, and he looked forward to the time when trade union policy would be altered to meet the requirements of professional men and professional associations. Then they might be able to fall into line with them, but they could not at present. He believed the Association would in the near future be duly recognised, and would have representation on works and industrial committees, and on Government forms of committees which were to control industries.

A number of members were enrolled.

RÖNTGEN SOCIETY.

March 5, 1918.

Captain G. W. C. Kaye in the Chair.

"*A Biological Basis for Protection against X-rays.*" By C. R. C. Lyster, M.R.C.S., and S. Russ, D.Sc.

In this contribution the study of the protection of X-ray operators was approached from a somewhat different point of view from that usually adopted. In previous investigations the materials have generally been tested to ascertain what fraction of the incident rays are transmitted, while in this case an attempt was made to measure the total quantity of radiation received by the operator during, say, a day's work under normal conditions. For this purpose the operator carries a photographic plate upon his person, and at the end of the period under consideration the plate is developed. The density of the resulting image is compared with that of another plate termed the "biological basis plate" which has been exposed under standard conditions of radiation. A preliminary investigation enables the harmful effects of the standard source of radiation to be determined and thus gives a meaning to the indication of the biological basis plate.

Radium forms a useful source of radiation for practical purposes after the initial tests have been made, and it overcomes difficulties in the employment of an X-ray tube, as a constant source.

The effect of hard and soft radiation (12 inch spark to 2 inch) on the photographic plate was fully investigated, and it was concluded that for the same ionising effect the hard and soft rays produced about the same photographic effect; the effect, however, varies with different makes of plates and in consequence all comparisons must in practice be made with the same variety.

"*A Mobile X-ray Unit.*" By H. C. Head.

A detailed description, illustrated by numerous photographs, was given of a motor X-ray unit recently designed and constructed for use in Mesopotamia, &c. The Austin chassis was chosen on account of its low load line, and the body was divided into two portions, one to serve as dark room, while the other contained the X-ray equipment. In operation a tent is erected at one side of the car, with the result that it is unnecessary to remove the coil or switchboard for use. Electric current is supplied from a dynamo run off the motor engine and from a small battery of accumulators, and is sufficient to render possible the production of short exposure radiographs.

The Röntgen Society has recently founded an annual lecture in memory of its first President, the late Professor Silvanus P. Thompson. The first "Silvanus Thompson Memorial Lecture" will be delivered by Professor Sir Ernest Rutherford, F.R.S., at the next meeting of the Society, to be held on Tuesday, April 9th, 1918, at 8 p.m. The council will be pleased to welcome all interested, and applications for cards of admission should be made to the Hon. Secretary of the Society, Dr. S. Russ, Middlesex Hospital, London, W.1.

Further particulars will be announced in due course.

NOTICES OF BOOKS.

Britain's Heritage of Science. By Arthur Schuster, F.R.S., and Arthur E. Shipley, F.R.S. London: Constable and Co., Ltd. 1917. Pp. xv+334. Price 8s. 6d. net.

This excellent book cannot be too highly recommended to teachers of science and to the educated general reader, who will find it a source of inspiration and of the keenest intellectual enjoyment. To show up clearly and in due proportion the salient features of British science is its aim, which has been achieved with complete success. The subject is divided into two—the physical and biological sciences, the former being considered first. The first chapter contains an account of the ten great men whose work may be said to constitute the landmarks of British science, and the subsequent chapters deal with the work of the universities in the seventeenth and eighteenth centuries, the non-academic heritage of the same period, the work of the nineteenth century which for adequate treatment was found to need two long chapters, industrial application of physical science, and, finally, scientific institutions. The plan adopted in discussing the biological sciences is rather different, the chapters dealing with the various branches—botany, zoology, physiology, and geology—after an introductory chapter on the work and knowledge of the middle ages. The part played by Great Britain in the development of science, which has been surpassed by no other nation, is clearly shown, and teachers of science will derive inestimable benefit from the book. It will point out to those who are trying to discover new and better ways of teaching how to make their work more effective for all classes of children, those who having marked ability are going to specialise in science, as well as those who have no very strong taste for the subject and are now usually allowed to remain in utter ignorance of its achievements, while often spending a comparatively large amount of time in learning the history of man's laws and wars and social institutions.

The Determination of Nitrogen in Substances used as Explosives. By W. C. Cope and Guy B. Taylor. Washington: Government Printing Office. 1817. P. 46. Price 10 cents.

This bulletin has been prepared in answer to frequent requests for details concerning the methods used by the Bureau of Mines for the determination of nitrogen in nitro-derivatives. Accurate and full accounts are given of the three processes usually employed—Dumas' method, the modified Kjeldahl method, and the phosphorus iodide method. The advantages and disadvantages of each process are pointed out and possible sources of error are discussed. A tabular statement of the theoretical results and those obtained by the three methods when applied to some twenty compounds is included, so that the degree of accuracy to be expected may be ascertained. The determination of nitrogen in nitrates by means of the du Pont and Lunge nitrometers is also included, and the bulletin will be exceedingly useful to chemists employed in explosives works. It contains full tables of data which are required in calculating the results in nitrogen determinations.

Society of Chemical Industry.—The next meeting of the London Section will be held at the Rooms of the Chemical Society, Burlington House, Piccadilly, W., on Monday, March 25, at 8 p.m., when the following paper will be read:—"Some Cotton Seed Products in Relation to Present Day Needs," by E. C. de Segundo, A.M.I.C.E., &c. The attention of members is especially directed to the change from the usual date of meeting, as the first Monday in April is Easter Monday.

CORRESPONDENCE.

RAMSAY MEMORIAL FUND.

To the Editor of the Chemical News.

Sir,—I desire to commend to the citizens of London the appeal which I am issuing in support of the Ramsay Memorial Fund. That fund aims at raising £100,000 as a suitable memorial to the great chemist, Sir William Ramsay, who was for twenty-six years connected with London through his work as a Professor of Chemistry at University College. The memorial will take the form of Fellowships in Chemical Science, with special reference to Industry and Technology, tenable in any Institution possessing the necessary accommodation and equipment, and of a Laboratory of Engineering Chemistry in connection with University College. Both objects are of the highest scientific importance, and it is fitting that London should make a substantial contribution, both in recognition of the honour brought to London by the connection with it of so distinguished a man of science as the late Sir William Ramsay and on account of the benefits which will accrue to the many industrial interests in London through the proposed Fellowships and Laboratory of Engineering Chemistry. Such an effort cannot fail to have a great significance as an essential element in reconstruction after the War.

Donations towards the London Fund of the Ramsay Memorial Appeal may be sent to me at the Mansion House.—I am, &c.,

Chas. A. Hanson, Lord Mayor.

The Mansion House, London, E.C. 4.
March 8, 1918.

City of London Committee.

Chairman.—The Lord Mayor of London (the Right Hon. Charles Augustin Hanson, M.P.)

Committee.—Alderman Sir Walter Wilkin, K.C.M.G.; Alderman the Right Hon. Sir T. Vezey Strong, K.C.V.O., K.B.E.; Alderman Sir Charles Wakefield, Bart.; Alderman Sir John Humphery; Alderman George Briggs; Captain and Sheriff G. Rowland Blades; Mr. Sheriff H. F. Hepburn; the Chairman of the Council of the London Chamber of Commerce (Lionel A. Martin, Esq.; the Chairman of the British Empire Producer's Organisation (C. Sandbach Parker, Esq.); Sir Ralph Collingwood Forster, Bart.; Sir Boverton Redwood, Bart., D.Sc., F.R.S.E.; Sir Archibald Williamson, Bart., M.P.; Sir Stanley Bois; Sir William Pearce, M.P.; Sir Edward Rosling; H. R. Beeton, Esq.; A. Chaston Chapman, Esq., F.I.C., F.C.S.; W. Bruce Dick, Esq.; C. J. Longman, Esq.; H. J. Morland, Esq.; John C. Nicholson, Esq.; W. H. Peat, Esq.; Stuart A. Russell, Esq.; E. T. Wilks, Esq.

Organising Secretary.—Walter W. Seton, Esq., M.A., D.Lit.

By the death in July, 1916, of Professor Sir William Ramsay, K.C.B., F.R.S., Science throughout the world suffered the loss of one of its most brilliant and distinguised leaders. For thirty-five years Sir William Ramsay occupied a foremost place in the ranks of scientific investigators, and his discoveries in the realm of Chemical Science had earned for him a world-wide reputation.

Sir William Ramsay spent twenty-six years of his professorial career at University College, London, and it was during those years that his most important scientific discoveries were made. His long association with London as a teacher and as a discoverer and a director of scientific research have reflected honour upon the City and the University of London.

A Memorial Committee, under the Presidency of the Right Hon. H. H. Asquith, was formed in October, 1916, at a meeting held at University College, London. The Executive Committee then appointed have resolved to aim

at raising a sum of £100,000, but it is their hope that the amount raised will be in excess of that sum.

The final form of the memorial will, in accordance with the terms of the main resolution passed at the Memorial Meeting, be submitted to the subscribers to the fund, and it will necessarily depend to a large extent upon the response which is made to the appeal. The Executive Committee have held several meetings at which careful and detailed consideration has been given to various alternative schemes for the proposed memorial which have been put forward. They consider, however, that there are two principal objects to which the larger part of the fund raised should be devoted, namely—

(i.) The provision of Ramsay Research Fellowships, *tenable wherever the necessary equipment may be* found, and

(ii.) The establishment of a Ramsay Memorial Laboratory of Engineering Chemistry in connection with University College, London.

The execution of these two projects, which are described in more detail below, does not, in the opinion of the Committee, preclude the utilisation of smaller sums for other suitable forms of memorial, such, for example, as the provision of a portrait for the National Portrait Gallery, or the placing of a bust or medallion in some suitable place, or the institution of an annual award of a Ramsay Gold Medal for Chemical Research.

Towards these objects a sum of over £30,000 has already been collected. Co-operating Committees have been formed for the purpose of collecting funds in Glasgow, in the principal British Colonies and Dependencies, and in many Allied and Neutral countries.

It appears desirable that a substantial sum should be raised in the City of London as a contribution to the Ramsay Memorial Fund. London has benefited largely in the past through Sir William Ramsay's connection with this City. London will benefit more directly than any other city in the proposed Memorial as the Laboratory of Engineering Chemistry will be in London and the Fellowships will be tenable in London, as well as elsewhere. Subscribers may earmark their subscriptions for either of the two purposes suggested above if they so desire. All desiring to subscribe are invited to send their contribution or promise to me at the Mansion House. A subscription form and envelope are enclosed for the purpose. Cheques should be drawn in favour of the Ramsay Memorial Fund and crossed London City and Midland Bank, Tottenham Court Road Branch.

CHAS. A. HANSON, Lord Mayor.

THE COMBINED UNIVERSITIES CONSERVATIVE AND UNIONIST ASSOCIATION.

To the Editor of the Chemical News.

SIR,—At a meeting of graduates of the Universities of Durham, Manchester, Liverpool, Leeds, Sheffield, Birmingham, and Bristol, held in London on Tuesday, March 12, it was decided to form a Conservative and Unionist Association for the new University Constituency, which comprises the above mentioned universities.

It is the object of the Association to do all in its power to further the interests of education, and, in particular, of higher education, while at the same time giving support to those fundamental political principles denoted by its title.

A Provisional Committee including the following officers was appointed:—Sir Maurice Abbot-Anderson, M.B., B.Sc., M.V.O., Chairman; Prof. J. Wemyss Anderson, M.Eng., Hon. Treasurer; Mr. Herbert G. Williams, M.Sc., M.Eng., Hon. Secretary.

It is proposed to elect a lady to fill the office of Vice-Chairman, but unfortunately none of the ladies present at the meeting could see their way to accept the office.

It is hoped to rectify this omission at an early date.

As no complete list of addresses of the graduates is available, may I ask the kind hospitality of your columns for the purpose of inviting all graduates of the seven universities, who approve of our action, to communicate with me, stating their university and degree.—I am, &c.,

HERBERT G. WILLIAMS, Hon Secretary.

130, Ashley Gardens, S.W. 1.,
March 14, 1918.

CHEMICAL FERTILISERS.

To the Editor of the Chemical News.

SIR,—May I take the liberty to ask one of your correspondents for a little information? I am a Belgian chemical fertiliser manufacturer, driven into exile and forced idleness through our common foe, who, after having dismounted the machinery, has just blown the place to pieces. In these conditions, as I shall have to rebuild a new plant, I should like also to try to make some products I did not produce before.

Consequently, I should be greatly obliged if you could let me know where I could find some information concerning the Haber process for the fixation of nitrogen and the Caro process for the manufacturing of calcium nitrate.

I think there must exist some literature about these processes. I hope I have not asked an impossibility, and thanking you in anticipation, I am, &c.,

ALB. BLOMME.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxv., No. 27, December 31, 1917.

This number contains no chemical matter.

Vol. clxvi, No. 1, January 7, 1918.

New Method of Preparing Aromatic Nitriles by Catalysis.—Alphonse Mailhe.—When vapours of methyl benzoate mixed with ammonia are passed over thorium oxide heated to 450—470°, a liquid is obtained which separates into two layers. One of these, which is aqueous, has an aldehydic reaction, and is formed by the decomposition of methyl alcohol into formaldehyde and hydrogen. The other layer when submitted to distillation yields benzonitrile, C_6H_5CN. The reaction, which provides a convenient method of preparing benzonitrile, is $C_6H_5CO.OCH_3+NH_3=C_6H_5CN+H_2O+CH_3OH$. A similar reaction occurs when ethylbenzoate is used, and ortho- and para-toluol nitriles and phenylacetonitrile can be made in the same way.

Distillation of Cellulose and Starch in a Vacuum.—Amé Pictet and J. Sarasin.—When pure cellulose is gradually heated under a pressure of 12 to 15 mm. a small quantity of water passes over, and then between 200° and 300° a heavy yellow oil is obtained, which sets to a pasty semi-crystalline mass. About 10 per cent of charcoal remains in the retort. The pasty mass forms about 45 per cent of the cellulose used. After it has been purified it gives white tabular crystals, the properties of which agree in all respects with those of Tanret's lævoglucosane. Starch behaves exactly like cellulose when distilled under reduced pressure.

Centrifugal Machines.—Messrs. A. Gallenkamp and Co., Ltd., have recently issued new lists of their centrifugal machines, some types of which will be found of special value in industrial laboratory work. They have also published a pamphlet (No. 191) on viscometers and flash-point apparatus, in which different forms of apparatus are illustrated and described and full directions are given for use. The firm will be pleased to send copies of these lists upon application to their offices at 19—21, Sun Street, Finsbury Square, E.C. 2.

THE CHEMICAL NEWS

Vol. CXVII., No. 3044

SPECIAL NOTICE TO SUBSCRIBERS.

We regret to announce that the recent paper restrictions will compel us for a period, until we can secure our usual supply of paper, to publish the Chemical News fortnightly instead of weekly.

The price will not be altered, except as regards the subscription price, which, until further notice, will be calculated at £1 for fifty-two numbers, or *pro rata*.

Subscribers will please note that the respective expiration dates of their subscriptions will be extended accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their extended subscription periods.

The next issue (No. 3045) will be published on April 12th.

FURTHER REMARKS ON THE ENERGY THEORY OF MATTER.

By H STANLEY REDGROVE, B.Sc. (Lond.), F.C.S

1. Considerable interest attaches to Mr. Vliet's attempt to calculate the contribution of the carbon and hydrogen atoms and bonds towards the molecular heats of combustion of their compounds ("The Energy Theory of Matter," Chemical News, 1918, cxvii., 118). Unfortunately, however, as I shall proceed to show, Mr. Vliet's calculations involve a mathematical fallacy which *invalidates his results completely*. *The argument by which* he proves that $4H - 4L_1 - C = 0$ is both ingenious and sound. (For the meaning of the symbols employed see my paper "A Contribution to the Energy Theory of Matter," Chemical News, 1917, cxvi., 37, or Mr. Vliet's contribution referred to above). The error consists in supposing that this constitutes a new equation in addition to—

$$C+4H = 210{\cdot}8 \text{ cals.}$$
$$2C+6H+L_1 = 369{\cdot}0 \text{ cals.}$$

—by means of which these equations can be solved for C, H, and L_1. For—

$$7(C+4H)-4(2C+6H+L_1) = 4H-4L_1-C.$$

That is to say, Mr. Vliet's new equation is *not* a new equation, but merely a combination of the two original equations. That its value is zero—or practically zero—can at once be deduced from these two equations. Thus—

$$\begin{aligned}4H-4L_1-C &= 7(C+4H)-4(2C+6H+L_1)\\ &= 7 \times 210{\cdot}8 \text{ cals.} - 4 \times 369{\cdot}0 \text{ cals.}\\ &= -0{\cdot}4 \text{ cals.}\end{aligned}$$

In other words, the equations—

$$C+4H = 210{\cdot}8,$$
$$2C+6H+L_1 = 369{\cdot}0,$$
$$4H-4L_1-C = 0,$$

—are indeterminate, and the solution Mr. Vliet gives is only one out of an infinite number of possible solutions. For instance,—

$$C = 0, \ H = 52{\cdot}7, \ L_1 = 52{\cdot}7,$$

—satisfies the equations just as well as Mr. Vliet's values, namely,—

$$C = 210{\cdot}8, \ H = 0, \ L_1 = 52{\cdot}7.$$

Hence the further knowledge requisite to the calculation of the values of these constants is not supplied by Dr. Thornton's observation, that the M.H.C. of a saturated hydrocarbon divided by the number of oxygen atoms required for the combustion of one molecule of that hydrocarbon is constant, upon which Mr. Vliet's computation is based; and the values of the constants in question remain indeterminate.

2. It is just because $7(C+4H)-4(2C+6H+L_1) =$ practically zero, or, in other words, because the M.H.C. of ethane is practically seven-fourths that of methane, that the M.H.C. of a saturated hydrocarbon divided by the number of oxygen atoms required for the combustion of one molecule of that hydrocarbon is constant. Consequently, there is no profound significance attaching to this fact, as Dr. Thornton appears to think. I should mention that in the paper referred to by Mr. Vliet (*Phil. Mag.*, 1917, xxxiii., 196 *et. seq.*), Dr. Thornton endeavours to show that this constancy holds, not only for saturated hydrocarbons, but for other organic compounds as well. The tables he has compiled do not, however, *bear out his contention, the quotient (M.H.C. ÷ No. of* O atoms required) showing very large variations from constancy indeed. Moreover, what degree of constancy is shown (apart from the case of saturated hydrocarbons, when the quotient is constant for the reason stated above) is largely spurious, and the result of Dr. Thornton's method of exhibiting his results. "The proof of the pudding is in the eating"—or, to put it more philosophically, the pragmatic test is the scientific one. If the quotient in question is constant for all the types of organic bodies Dr. Thornton enumerates, it ought to be possible, having determined its average or most probable value, to calculate by means of it the molecular heats of combustion of all the bodies in question. This is one method I have invariably adopted for testing my own theories concerning physico-chemical properties, and it affords, I submit, a very necessary criterion. Now, if Dr. Thornton, or anyone else who may be interested, will carry out the needed arithmetic, he will at once see, in view of the very large divergences between calculated and experimental results in numerous instances, the futility of Dr. Thornton's contention.

Further, as regards Dr. Thornton's paper, it should be *noted that he commences by asserting the values of C and* H (not including C.H), in spite of the fact that it has been proved that the values of these constants are—in the present state of knowledge, at any rate,—indeterminate.

3. Three hypotheses can be made concerning the composition of bodies. I do not say they exhaust the possibilities, but they seem the most promising from the physico-chemical standpoint. They are:—

(1) Bodies are made up of atoms only.
(2) Bodies are made up of atoms plus valency-bonds or energy-units.
(3) *Bodies are made up of energy-units—the so-called* valency-bonds—only.

Hypothesis 1 appears to be the atomic theory in its original form before undergoing the evolution into its present condition. Were it true, physico-chemical properties should invariably be "additive" in the strict sense, and no energy change should accompany any chemical reaction. It is, of course, quite untenable; but it appears to be the idea underlying the older method of calculating physico-chemical constants, according to which the influences of such links as the C.C, C.H, &c., on physico-chemical properties were neglected, and "unsaturated" bodies—which, consequently, would not fall

into line—were treated as exceptional. (The method of calculating thermo-chemical constants, devised by Julius Thomsen, though fallacious, as I have shown in an appendix to my "On the Calculation of Thermo-chemical Constants," 1909, must be excepted from the above statement). In past papers in the Chemical News and in the above-mentioned book, I have, I hope, sufficiently exposed the fallacy of this method as to render further criticism of it unnecessary.

Hypothesis 2 is the "*safest*" *of the three hypotheses*, because, in a sense, it includes the other two. It is the hypothesis underlying my own method of calculating the values of physico-chemical properties of an additive or partly additive nature, by means of the so-called "fundamental constants," as explained in the papers and the *work referred to above*. I used to hope that, although the values of the isolated atoms and bonds were at the moment indeterminate, some new knowledge might, in the future, render their calculation possible. I now begin to doubt this, so long as the hypothesis in question is adhered to. For, in accordance with this hypothesis, isolated atoms *and isolated* bonds are *non-existent*—unless, as concerns the former, monatomic gases constitute a case in point. Whilst the "fundamental constants," C+4H, 2H−L_1, &c., refer to real phenomena, real operations, or combinations of such, the separate symbols do not; they represent, not reality, but an arbitrary analysis of reality by the mind.

Hypothesis 3, which is the "energy theory of matter" as formulated in my previous paper on the topic, provides a way of escape from this state of indeterminateness. According to it, for instance, C.H indubitably represents reality, for methane is no longer a compound of C and H (I am here using the symbol H to stand for the hydrogen atom alone) only—as on the first hypothesis—or of C, H, and C.H—as on the second—but of C.H alone. It is composed entirely of the energy-units represented by C.H. It is 4(C.H).

But if the equations—

$$C+4H = a$$

$$2C+6H+L_1 = b$$

(when *a* and *b* are known numerical quantities)—are indeterminate, why, it may well be asked, assume C=0, which is what the "energy theory of matter" seems to do, rather than any other number? The reason I have explained in the previous paper already referred to; but it may be as well to amplify it on the present occasion. If we know the number and sort of valency-bonds which constitute a body according to hypothesis 3, or are present in it according to hypothesis 2, then it is possible to calculate the number and sort of atoms it also contains according to the latter hypothesis, or which entirely constitute *it according to hypothesis* 1. But *the converse is not true*. Hence, if we know the number and sort of valency-bonds, we can calculate, by assigning a constant value to each sort, the value of any physico-chemical property of a body of known constitution (according to hypotheses 2 or 3), which is strictly additive (*i.e.*, depends only upon the number and sort of atoms present according to hypotheses 1 and 2; *e.g.*, molecular weight), or partly additive (*i.e.*, depends upon both the number and sort of atoms present according to hypotheses 1 and 2, as well as upon the valency-bonds postulated by the latter; *e.g.*, molecular heat of combustion, molecular heat of formation, molecular refractivity, molecular dispersion, molecular volume, &c.). In other words, all such properties of bodies are functions of the number and sort of valency-bonds present in, or constituting, them. On the other hand, we cannot calculate the value of any such property—but only that of a strictly additive property—*if we know only the number and* sort of atoms in the body, and neglect the valency-bonds. We may neglect the atoms, but not the bonds. Thus, *from the* physico-chemical standpoint—or, at any rate, so far as the physico-chemical properties in question are concerned—bodies behave *as if* they were made up purely of valency-bonds; and I do not know what test other than behaviour can be applied to determine whether they *are* so constituted. The one difficulty that does present itself is the case of monatomic gases. Study of their physico-chemical properties should prove of importance in this connection. But in any case the question arises, What constitutes the difference between atom and molecule in the case of such a gas?

In *conclusion, I would say that of all the possible* hypotheses by means of which additive and partly additive physico-chemical properties of bodies may be calculated, that based on the "energy theory of matter" appears to be the simplest, and, so far as actual results go, the values of such properties calculated by means of it are identical with those *given* by the more elaborate method of "fundamental constants." And I would repeat that "the proof of the pudding is in the eating."

West Ham Municipal Technical Institute,
Stratford, Essex.

SOME COTTON SEED PRODUCTS IN RELATION TO PRESENT DAY NEEDS.*

By Ed. C. de Segundo, A.M.I.C.E., M.I.Mech.E., M.I.E.E.

Attention was directed to the value of certain products obtainable from cotton seed—and more particularly that of the "Upland" or "Woolly" varieties—in dealing with some of the economic problems which, as a direct consequence of the war, have become acute, but which would, in any event, have had to be faced sooner or later:—

1. In relation to the production from the kernels of the cotton seed, when separated from the containing envelope, of a grade of edible oil admittedly superior to that obtained by the method now practised in Great Britain, and pre-eminently suitable for the manufacture of the highest qualities of margarine and artificial lard.

2. In relation to the employment of the residue of the kernels after expression of the oil, in the manufacture of *flour containing about five times the food value of* wheat flour, for admixture with wheat flour and for other dietetic purposes.

3. In relation to the utilisation of the hitherto neglected *short cotton fibres remaining upon the shell of* the woolly varieties of cotton seed after ginning for the manufacture of explosives, paper, artificial silk, cellulose acetate, and other cellulose derivatives.

The two main categories into which cotton seed may, for practical purposes, be divided were outlined, and the salient features of the British and American systems of milling cotton seed reviewed. Figures were quoted in support of the view that the best practice in each system indicates a higher percentage extraction of a superior grade of oil is obtained by the American method than by the British method.

The important influence upon the industrial value of the woolly varieties (when treated by the American method) of recently introduced mechanical devices for turning to commercial account the short cotton fibres above referred to was dealt with, and it was pointed out that hitherto these short cotton fibres had been practically wasted in the United States, and that on the British system they still continue to be incorporated in the residue of the seed (after the oil has been expressed) which is employed as a feed for cattle, and that the presence of cotton fibre in such feed detracts from its food value.

Samples were exhibited of these short cotton fibres, of which many thousand tons have already been employed in the United States for the manufacture of explosives, and of which increasing quantities, imported from the

* *Abstract of a Paper read before the Society of Chemical Industry* (London Section), March 25, 1918.

United States, were being used in Great Britain up to the outbreak of the war in the manufacture of high-grade paper. Samples of bread made from a mixture of cotton seed flour and wheat flour were also shown.

Reasons are adduced for the backward and unscientific position, taken as a whole, of the British seed crushing industry, and attention was called to the fact that whereas in the year 1905 British oil mills crushed 94·4 per cent of the cotton seed produced in Egypt, the proportion had sunk in 1913 to 51·6 per cent, owing to the expansion of the seed crushing industry in Germany which had also then succeeded in practically monopolising the crushing of the richer oil bearing seeds.

It was pointed out that the spinning industry of Lancashire is seriously menaced by the rapidly increasing proportion of cotton grown in the United States that is being spun in American mills, and by a similar movement in India (and also by the increasing exports of cotton from India to Japan), and attention was drawn to the immense areas within the Empire—notably in the Anglo-Egyptian Sudan—where the cultivation of cotton has already been proved to be commercially practicable.

The advantages, both financial and industrial, which would attend the organisation of the cotton growing and the cotton seed milling industries on proper business and scientific lines were dwelt upon; it was recommended that those in authority seriously examine into the advantages offered by the American method of milling cotton seed (particularly in view of the now commercially proved devices for recovering the hitherto neglected short cotton fibres on the woolly varieties of seed) with a view to promote the welfare of the industries above referred to, for the expansion of which literally unlimited opportunities will offer upon the conclusion of the war.

THE COMPLEXITY OF THE CHEMICAL ELEMENTS.*

By Prof. FREDERICK SODDY, M.A., F.R.S.

THE elements of the chemist are now known to be complex in three different senses. In the first sense the complexity is one that concerns the general nature of matter, and, therefore, of all the elements in common to greater or less degree. It follows from the relations between matter and electricity which have developed gradually during the past century as the result of experiments made and theories born within the four walls of this Institution. Associated initially with the names of Davy and Faraday they have only in these days come to full fruition as the result of the very brilliant elucidation of the real nature of electricity by your distinguished Professor of Physics, Sir Joseph Thomson. Such an advance, developing slowly and fitfully, with long intervals of apparent stagnation, needs to be reviewed from generation to generation, disentangled from the undergrowth that obscures it, and its clear conclusions driven home. This complexity of the chemical elements is a consequence of the condition that neither free electricity nor free matter can be studied alone, except in very special phenomena. Our experimental knowledge of matter in quantity is necessarily confined to the complex of matter and electricity which constitutes the material world. This applies even to the "free" elements of the chemist, which in reality are no more free then than they are in their compounds. The difference is merely that, whereas in the latter the elements are combined with other elements, in the so-called free state they are combined with electricity. I shall touch but briefly on this first aspect, as in principle it is now fairly well understood. But its consistent and detailed application to the study of chemical character is still lacking.

The second sense in which the elements, or some of them at least, are known now to be complex has, in sharp contrast to the first, developed suddenly and startlingly from the recognition in radioactive changes, of different radio-elements, non-separable by chemical means, now called isotopes. The natural corollary of this is that the chemical element represents rather a type of element, the members of the type being only chemically alike. Alike they are in most of those properties, which were studied prior to the last decade of last century, and which are due, as we now think, to the outer shells of the atom, so alike that all the criteria, hitherto relied upon by the chemist as being the most infallible and searching, would declare them to be identical. The apparent identity goes even deeper into the region reached by X-ray spectrum analysis which fails to distinguish between them. The difference is found only in that innermost region of all, the nucleus of the atom, of which radioactive phenomena first made us aware.

But though these phenomena pointed the way, and easily showed to be different to what the chemist and spectroscopist would have decided to be identical, it did more. It showed that although the finer and newer criteria, relied upon by the chemist in his analysis of matter, must of necessity fail in these cases, being ultimately electrical in character, yet the difference should be obvious in that most studied and distinctive characteristic of all—the criterion by which Dalton first distinguished the different kinds of atoms—the atomic weight. Those who have devoted themselves to the exact determination of these weights have now confirmed the difference in two separate cases, which, in absence of what perhaps they might regard as "preconceived notions," they were unable to discover for themselves. This is the experimental development *to which I wish more especially to direct your* attention. It indicates that the chemical analysis of matter is, even within its own province, superficial rather than ultimate, and that there are indefinitely more distinct elements than the ninety-two possible types of element accommodated by the present periodic system.

The third sense in which the elements are known to be complex *is that which, in the form of philosophical speculations*, has come down to us from the ancients, which inspired the labours of the alchemists of the Middle Ages, and which in the form of Prout's hypothesis has reappeared in scientific chemistry. It is the sense that denies to Nature the right to be complex, and from the earliest times, faith out-stripping knowledge, has underlain the belief that all *the elements must be built up of the same primordial stuff*. The facts of radioactive phenomena have shown that all the radio-elements are indeed made up out of lead and helium, and this has definitely removed the question from the region of pure speculation. We know that helium is certainly a material constituent of the elements in the Proutian sense, and it would be harmless, if probably fruitless, to anticipate the day of fuller knowledge by atom building and unbuilding on paper. Apart altogether from this, however, the existence of isotopes, the generalisation concerning the Periodic Law that has arisen from the study of radioactive change on the one hand and the spectra of X-rays on the other, and experiments on the scattering of α-particles by matter, do give us for the first time a definite conception as to what constitutes the difference between one element and another. We can say how gold would result from lead or mercury, even though the control of the processes necessary to effect the change still eludes us. The nuclear atom proposed by Sir Ernest Rutherford, even though admittedly it is only a general and incomplete beginning to a complete theory of atomic structure, enormously simplifies the correlation of a large number of diverse facts. This and what survives of the old electronic theory of matter, in so far as it attempted to explain the Periodic Law, will therefore be briefly referred to in conclusion.

The Free Element a Compound of Matter and Electricity.

Although Davy and Faraday were the contemporaries of Dalton, it must be remembered that it took chemists

* A paper read before the Royal Institution, May 18, 1917.

fifty years to put the atomic theory on a definite and unassailable basis, so that neither of these investigators had the benefit of the very clear view we hold to-day. Davy was the originator of the first electro-chemical theory of chemical combination, and Faraday's dictum, "the forces of chemical affinity and electricity are one and the same," it is safe to say, inspired all the modern attempts to reduce chemical character to a science in the sense of something that can be measured quantitatively, as well as expressed qualitatively. Faraday's work on the laws of electrolysis and the discovery that followed from it, when the atomic theory came to *be fully developed, that all monovalent* atoms or radicles carry the same charge, that divalent atoms carry twice this charge and so on, can be regarded to-day as a simple extension of the law of multiple proportions from compounds between matter and matter to *compounds between matter and electricity*. Long before the electric charge had been isolated, or the properties of electricity divorced from matter discovered, the same law of multiple proportions which led, without any possibility of escape, to an atomic theory of matter, led, as Helmholtz pointed out in his well known Faraday lecture to the Chemical Society in this Theatre in 1881, to an atomic theory of electricity.

The work of Hittorf on the migration of ions, the bold and upsetting conclusion of Arrhenius that in solution many of the compounds hitherto regarded as most stable exist dissociated into ions, the realisation that most of the reactions that take place instantaneously, and are utilised for the identification of elements in chemical analysis, are reactions of ions rather than of the element in question, made very familiar to chemists the enormous difference between the properties of the elements in the charged and in the electrically neutral state.

More slowly appreciated, and not yet perhaps sufficiently emphasised, was the unparalleled intensity of these charges in comparison with anything that electrical science can show, which can be expressed tritely by the statement that the charge on a milligrm. of hydrogen ions would raise the potential of the world 100,000 volts. Or, if we consider another aspect, and calculate how many free hydrogen ions you could force into a bottle without bursting it, provided, of course, that you could do so without discharging the ions, you would find that, were the bottle of the strongest steel, the breech of gun, for example, it would burst, by reason of the mutual repulsion of the charges, before as much was put in as would, in the form of hydrogen gas, show the spectrum of the element in a vacuum tube.

Then came the fundamental advances in our knowledge of the nature of electricity, its isolation as the electron, or atom of negative electricity, the great extension of the conception of ions to explain the conduction of electricity through gases, the theoretical reasoning, due in part to Heaviside, that the electron must possess inertia inversely proportional to the diameter of the sphere on which it is concentrated by reason of the electro-magnetic principles discovered by Faraday, leading to the all-embracing monism that all mass may be of electro-magnetic origin.

This put the coping-stone to the conclusion that the elements as we apprehend them in ordinary matter are always compounds. In the "free" state they are compounds of the element in multiple atomic proportions with the electron. The ions, which are the real chemically uncombined *atoms of matter, can no more exist free in* quantity than can the electrons.

The compound may be individual as between the atom and the electron, or it may be statistical, affecting the total number merely of the opposite charges, and the element presumably will be an insulator or conductor of electricity accordingly. Analogously, with compounds, the former condition applies to unionised compounds, such as are met with in the domain of organic chemistry, or ionised, as in the important classes of inorganic compounds, the acids, bases, and salts. Just as the chemist has long regarded the union of hydrogen and chlorine as preceded by the decomposition of the hydrogen and chlorine molecule, so he should now further regard the union itself as a decomposition of the hydrogen atom into the positive ion and the negative electron, and a combination of the latter with the chlorine atom.

One of the barriers to the proper understanding and quantitative development of chemical character from this basis is, perhaps, the conventional idea derived from electrostatics, that opposite electric charges neutralise one another. In atomic electricity or chemistry, though the equality of the opposite charges is a necessary condition *for existence, there is no such thing as neutralisation*, or the electrically neutral state. Every atom being the seat of distinct opposite charges, intensely localised, the state of electric neutrality can apply only to a remote point outside it, remote in comparison with its own diameter. We are getting back to the conception of Berzelius, with some possibility of understanding it, that the atom of hydrogen, for example, may be strongly electro-positive, and that of chlorine strongly electro-negative, with regard to one another, and yet each may be electrically neutral in the molar sense. Some day it may be possible to map the electric field surrounding each of the ninety-two possible types of atoms, over distances comparable with the atomic diameter. Then the study of chemical character would become a science in Kelvin's sense, of something that could be reduced to a number. But the mathematical conceptions and methods of attack used in electrostatics for macroscopic distances are ill-suited for the purposes of chemistry, which will have to develop methods of its own.

We have to face an apparent paradox that the greater the affinity that binds together the material and electrical constituents of the atom the less is its *combining* power in the chemical sense. In other words, the chemical affinity is in inverse ratio to the affinity of matter for electrons. The helium atoms offer a very simple and instructive case. Helium is non-valent and in the zero family, possessing absolutely no power of chemical combination that can be detected. Yet we know the atom possesses two electrons, for in radioactive change it is expelled without them as the α-particle. The discharge of electricity through it and positive-ray analysis show that the electrons, or certainly one of them, are detachable by electric agencies, although not by chemical agencies. One would expect helium to act as a diad, forming helides analogous to oxides.

Prof. Armstrong for long advocated the view that these inert gases really are endowed with such strong chemical affinities that they are compounds that have never been decomposed. They certainly have such *strong affinities* for electrons that the atom, the complex of the + ion and electrons, cannot be decomposed chemically. Yet, in this case, where the affinity of the matter for the electron is at a maximum, the chemical combining power is absent.

These gases seem to furnish the nearest standard we have to electric neutrality in the atomic sense. The negative charge of the electrons exactly satisfies the positive charge of the matter, and the atomic complex is chemically, because electrically, neutral. In the case of the electro-positive elements, hydrogen and the alkali-metals, one electron more than satisfies the positive charge on the ion, and so long as the equality of opposite charges is not alt red, the electron tries to get away. In the case of the electro-negative elements, such as the halogens, the nega*tive charge, though equal presumably to the positive*, is not sufficient to neutralise the atom. Hence these groups show strong mutual affinity, one having more and the other less negative electricity than would make the system atomically neutral like helium. The electron explains well the merely numerical aspect of valency. But chemical combining power itself seems to require the idea that equal and opposite charges in the atomic sense are only exactly equivalent in the case of the inert gases. None of these ideas are now new, but their consistent application to the study of chemical compounds seems curiously to hang fire, as though something were still lacking.

It is so difficult for the chemist consistently to realise that chemical affinity is due to a dissociating as well as to a combining tendency and is a differential effect. There is only one affinity probably, and it is the same as that between oppositely charged spheres. But, atomic charges being enormous and the distances over which they operate in chemical phenomena being minute, this affinity is colossal, even in comparison with chemical standards. What the chemist recognises as affinity is due to relatively slight differences between the magnitude of the universal tendency of the electron to combine with matter in the *case of the different atoms. Over all is the necessary* condition that the opposite charges should be equivalent, but this being satisfied, the individual atoms display the tendencies inherent in their structure, some to lose, others to gain electrons, in order, as we believe from Sir Joseph Thomson's teaching, to accommodate the number of electrons in the outermost ring to some definite number. Chemical affinity needs that some shall lose as well as others gain. Chemical union is always preceded by a dissociation. The tendency to combine only is specific to any particular atom, but the energy and driving power of combination is the universal attraction of the + for the − change of matter for the electron.

The Electrical Theory of Matter.

Another barrier that undoubtedly exists to the better appreciation of the modern point of view, even among those most willing to learn, is the confusion that exists between the earlier and the present attempt to explain the *relation between matter and electricity. We know negative* electricity apart from matter as the electron. We know positive electricity apart from the electron, the hydrogen ion, and the radiant helium atom or α-particle of radioactive change for example, and it *is* matter in the free or electrically uncombined condition. Indeed, if you want to find matter free and uncombined, the simple elementary particle of matter in the sense of complexity being discussed, you will go, paradoxically, to what the chemist terms a compound rather than to that which he terms the free element. If this compound is ionised completely it constitutes the nearest approach to matter in the free state. Thus all acids owe their common acidic quality to really *free hydrogen, the hydrogen ion, a particle more different* from the hydrogen atom than the atom is from the hydrogen molecule.

Positive electricity is thus emphatically not the mere absence of electricity, and any electrical theory of matter purporting to explain matter in terms of electricity does so by the palpable sophistry of calling two fundamentally different things by the same name. The dualism remains whether you speak of matter and electricity, or of positive and negative electricity, and the chemist would do well to stick to his conception of matter *until* the physicist has got a new name for positive electricity which will not confuse it with the only kind of electricity that can exist apart from matter.

On the other hand, the theory of the electro-magnetic origin of mass or inertia is a true monism. Its tries to explain consistently two things—the inertia of the electron and the inertia of matter—by the same cause. The inertia of the former being accounted for by the well-known electro-magnetic principles of Faraday, by the assumption that the charge on the electron is concentrated into a sphere of appropriate radius; the 2000-fold greater inertia of the hydrogen ion, for example, can be accounted for by shrinking the sphere to one-two-thousandth of the electronic radius.

But the electrical dualism remains completely unexplained. Call the electron E and the hydrogen ion H. The facts are that two E's repel one another with the same force and according to the same law as two H's repel each other, or as an H attracts an E. These very remarkable properties of H and E are not explained by the explanation of the inertia. Are E and H made up of the same stuff or of two different stuffs? *We do not know*, and certainly have no good reason to assume, that matter minus its electrons is made of the same thing as the electron. We have still to reckon with two different things.

(To be continued).

IONISATION AND POLYMERISATION IN CADMIUM IODIDE SOLUTIONS.*

By R. G. VAN NAME and W. G. BROWN.

It is a well-known fact that water solutions of cadmium iodide show an abnormally low electrical conductivity and freezing-point lowering as compared with other salts of like type. This is generally ascribed to the presence in the solution of complex molecules and ions. In a previous article (*Am. Journ. Sci.*, 1917, [4], xliv., 105) we have described a method, based on the measurement of distribution coefficients of iodine between such a solution and a non-aqueous phase, by which it is possible, by extrapolation, to calculate the percentage of simple molecules and ions in a pure solution of cadmium iodide. The application of this method led to the conclusion that in 0·5-molar cadmium iodide at 25° about 6 per cent was present in the form of simple CdI_2 molecules, ionised and non-ionised, in 0·25-molar solution, 10·6 per cent in 0·125-molar solution 16·8 per cent, and in 0·01-molar solution 55 per cent.

These results may be compared with those of Walton (*Zeit. Phys. Chem.*, 1904, xlvii., 185), who showed in 1904 that the rate of decomposition of hydrogen peroxide in a neutral solution containing an iodide is proportional to the concentration of the iodine ion, and used this kinetic method to determine the proportion of iodine ion in a series of rather dilute cadmium iodide solutions. With due allowance for ionisation and for differences in concentration, our results, as will be shown later, are consistent with those of Walton, at least as to order of magnitude.

McBain (*Zeit. Elektrochem.*, 1905, xi., 215), on the other hand, by a mathematical analysis of the data in the literature concerning conductivity, freezing-points, and *transport numbers of cadmium iodide solutions*, has arrived at quite a different result. McBain concludes that in a 0·1-molar cadmium iodide solution, the only concentration quantitatively dealt with, most of the salt is in the form of simple non-ionised CdI_2 molecules, and that the complexes make up only about 8 per cent of the whole.

In the present investigation we have attempted to throw further light upon this question by a study of solutions of cadmium iodide containing dissolved iodine, by means of *measurements of electromotive force and of freezing-point* lowering.

Electromotive Force Measurements.

The reversibility and reproducibility of iodine electrodes composed of platinum immersed in an iodide solution containing free iodine, have been proved by the work of a number of investigators (see, for example, Maitland, *Zeit. Elektrochem.*, 1906, xii., 263; also Jones and Hartmann, *Journ. Am. Chem. Soc.*, 1915, xxxvii., 757). In its relation to the present problem the work of Laurie is especially important (*Zeit. Phys. Chem.*, 1909, lxvii., 627). Laurie used the electromotive force of concentration cells composed of two such iodine electrodes as a means of calculating the iodine ion concentration in a potassium iodide solution saturated with iodine. The Nernst equation for the electromotive force of such a cell at 25° may be written—

$$1.\quad \pi = 0{\cdot}02955\left\{\left(\log\frac{(I_2)}{(I')^2}\right)_{\text{Sol. 1}} - \left(\log\frac{(I_2)}{(I')^2}\right)_{\text{Sol. 2}}\right\}.$$

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* From the *American Journal of Science*, xliv., p. 453.

The electromotive force is thus stated in terms of four concentrations. Under the conditions of Laurie's experiments three of these four concentrations were calculable from known data, and the fourth, the desired iodine-ion concentration, was calculated from the observed electromotive force. Concentrated ammonium nitrate solution was used to eliminate diffusion potentials.

The method pursued in our own experiments was similar to that of Laurie. The cells measured were of the type—

$$Pt : KI+I_2 \text{ (saturated)} : NH_4NO_3 : CdI_2+I_2 : Pt.$$

Each cadmium iodide electrode was measured against two different potassium iodide electrodes of different concentrations, designated hereafter as electrodes A and B respectively, the former containing 0·1 molar KI, the latter 0·01 molar KI, both saturated with iodine. These two electrodes were then measured against each other, thus furnishing a check upon the results. All necessary data concerning these iodine-potassium iodide solutions have been given by Bray and MacKay (*Journ. Am. Chem. Soc.*, 1910, xxxii., 914).

As intermediate solution to eliminate diffusion potentials, a concentrated solution of ammonium nitrate was employed to which, following a suggestion due to Lother (see Bjerrum, *Zeit. Phys. Chem.*, 1905, liii., 438), enough sodium nitrate was added to make the mean cation velocity the same as that of the anion. This solution contained 8·3 mols. NH_4NO_3 and 1 mol. $NaNO_3$ per litre. For comparison a few measurements were made in which saturated potassium chloride solution was substituted for the mixed nitrates, but the results failed to show any difference large enough to be of importance in the present work. The nitrate solution was used in all the experiments recorded below.

Calculation of the diffusion potential by the Planck or the Henderson equation was practicable only when the ion concentrations of both solutions were known, which was true in the case of the cell made up of the two potassium iodide electrodes, but not for a cell with a cadmium iodide electrode. For the potassium iodide concentration cell the value of the diffusion potential was calculated with the aid of the following data taken from the article of Bray and MacKay:—

	Solution 1 0·1 molar.	Solution 2 0·01 molar.		Migration velocities.
(K^+)	0·0865	0·00941	:	74·8
(I')	0·0430	0·00484	:	76·5
(I'_3)	0·0435	0·00457	:	41·5

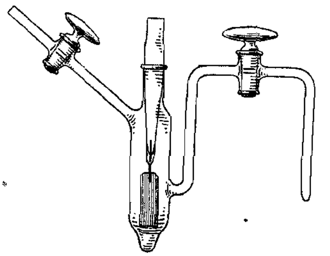
Using the Planck formula the value of the potential so obtained was 0·0070 volt, while the Henderson formula gave from the same data the value 0·0069 volt. The measured value, as given by the difference between the electromotive force as observed with and without the use of the intermediate nitrate solution, was approximately 0·003 volt.

In the opinion of the writers this difference between the measured and calculated values of the diffusion potential is too large to be explained by experimental error, or by uncertainty in the data employed in the calculation, and is to be ascribed to some peculiarity in the behaviour of liquid junctions which involve the tri-iodide equilibrium. Support for this view is given by the fact that the diffusion of iodine in an iodide solution is abnormal in at least one important respect, for the rate of diffusion of iodine in potassium iodide is known to increase with increasing concentration of the latter, while by the rule of Abegg and Bose we should expect just the reverse (*Zeit. Phys. Chem.*, 1899, xxx., 551). That the discrepancy is in all probability not due to the incomplete elimination of the diffusion potential by the nitrate solution is shown by the fact that the electromotive force of this concentration cell as measured with the nitrate solution as intermediate liquid (mean value of many determinations, 0·0560 volt), was in close agreement with the value calculated from Equation 1 (0·0561 volt).

Apparatus.—The type of half-cell used is shown in the figure. The tube carrying the electrode (of bright platinum-foil) was fitted into the neck of the half-cell by a ground joint, so that the iodine solution came in contact with nothing but platinum and glass. Two such cells were clamped in a frame with their syphon tubes dipping into opposite arms of a U tube containing the intermediate solution, and the whole was immersed up to the necks of the half-cells in a thermostat kept at 25°. With stopcocks closed the cell could be left set up for many days without danger of contamination of the solution, and could quickly be put into commission again by emptying the syphon arms and renewing the intermediate liquid. The stopcocks in the syphon arms were generally left open during the actual measurement. In the earlier experiments, contact between dissimilar solutions was brought about in the U-tube in a layer of sea-sand, as recommended by Bjerrum (*Zeit. Elektrochem.*, 1911, xvii., 58, 389), but the use of sand was later abandoned as troublesome and unnecessary for the present purpose.

The measurements were made by the Poggendorf compensation method with the aid of a galvanometer sensitive to 4×10^{-9} ampères. Owing, however, to the high resistance of the cells measured, the accuracy of a single bridge-reading did not much exceed 1 millivolt.

Preparation of the Reference Electrodes.—The complete saturation of the iodide solutions with iodine was accomplished by sealing the solution with powdered iodine in a



large glass tube, which was attached to the stirring axis of the thermostat, and rotated for a period of at least twenty-four hours. With solutions so prepared the two reference electrodes, when measured against one another, usually gave a constant potential difference within twelve hours, which retained its value practically unchanged for many days. Occasional shaking of the half-cells (which contained a little solid iodine) was found to favour constant results. The liquid in the syphon arms was emptied periodically, and the half-cell when necessary could be refilled with a portion of the original (iodine saturated) solution without altering the measured electromotive force. All measurements were at 25° C.

Experimental Procedure.—A cell composed of the two reference electrodes was first set up, and its electromotive force measured from time to time until the constant value 0·056 volt was reached. A half-cell was then filled with the iodine cadmium iodide solution to be investigated, and measured in turn against each of the reference electrodes. Finally, as a check, the reference electrodes were again combined and measured. Obviously the difference between the electromotive forces of the two cells in which the iodine cadmium-iodide electrode was used should agree with the electromotive force of the cell made up of the two reference electrodes (0·056 volt). All measurements in which the difference above mentioned was within ±0·001 volt of 0·056 volt were considered trustworthy.

TABLE I.

Dissolved iodine.	(I_2).	E.M.F. volt against— A.	B.	(I').	(I') mean.
		0·5 molar CdI_2.			
55·5 (*a*)	1·32	0·0423		25·1	25·3
			−0·0134	25·5	
39·29	0·955	0·0504		29·3	30·0
			−0·0046	30·7	
26·06	0·605	0·0536		26·5	26·9
			−0·0029	27 3	
21·63	0·505	0·0589		29 7	30·2
			0·0037	30·8	
13·44	0·315	0·0648		29·5	29·7
			0·0090	29·8	
7·57	0·175	0·0725		29 7	30·6
			0·0178	31·5	
6·02	0·140	0·0751		29·4	30·2
			0 0203	30·9	
0·0	0·0				30·4
		0·25 molar CdI_2.			
45·35 (*a*)	1·32	0·0470		30·2	29·7
			−0·0099	29 2	
36·24	0·99	0·0490		28·3	28·8
			−0·0063	29·2	
20 4	0·538	0·0592		31·0	30·8
			0·0027	30·5	
9·69	0·255	0·0689		31·1	30·9
			0·0124	30·7	
6·02	0·160	0·0745		30·4	31·1
			0·0193	31·8	
3·387	0·090	0·0818		30 6	31·2
			0·0267	31·8	
0·0	0·0				31·2
		0·125 molar CdI_2.			
35·7 (*a*)	1·32	0·0423		25·1	25·6
			−0·0137	26·0	
18·63	0·648	0·0531		26·9	27·4
			−0 0021	27 8	
7·26	0·250	0·0675		29 2	29·1
			0·0112	29 0	
3·443	0·110	0·0770		28·1	28·3
			0·0213	28·5	
1·641	0·051	0·0870		28·3	28·5
			0·0313	28·7	
0·792	0·022	0·0962		26 5	27·0
			0·0410	27·5	
0·0	0·0				27·5
		0·01 molar CdI_2.			
8·16 (*a*)	1·32	0·0080		6·62	6·79
			−0·0468	6·95	
2·540	0·2967	0·0342		8 69	9·16
			−0·0193	9·62	
1·397	0·1569	0·0431		8 95	9·23
			−0·0114	9·52	
0·646	0·0713	0·0535		8·94	8·94
0·3104	0·0343	0·0654		9·93	10·42
			0·0116	10 90	
0·1411	0·0168	0·0755		10 36	10·77
			0·0216	11·27	
0·0	0·0				10·50

(*a*) Solution saturated with iodine.

The cadmium iodide solutions used were of four different concentrations, 0·5, 0·25, 0·125, and 0·01 molar, from each of which a number of electrodes containing varying amounts of dissolved iodine were prepared and measured against electrodes A and B. Since these concentrations of cadmium iodide were the same as employed in the determinations of distribution coefficients described in our previous article (*Am. Journ. Sci.*, 1917, [4], xliv., 105) the results of that work were used in calculating (I_2), the concentration of uncombined iodine, from the concentration of dissolved iodine as found by direct titration. *For electrodes A and B* (I_2) was obviously equal to 0·00132, the solubility of iodine in pure water, and the values of (I') for these two solutions were those given above in this article. It was therefore possible to calculate (I') for each cadmium iodide solution from the observed *electromotive force by means of Equation 1.*

A summary of the results is given in Table I. Except where otherwise stated, concentrations in this and the following tables are expressed in millimols per litre. In the third column are the potential differences given by each iodine-cadmium iodide electrode against reference electrode A, while the potential difference for the same electrode against reference electrode B is found in the fourth column on the horizontal line next below. A negative sign prefixed to the recorded potential indicates that the reference electrode formed the negative pole. Usually the reverse was true. The iodine ion concentrations calculated from these potential differences are recorded in the fifth and sixth columns, the former giving the two independent values for each solution, derived from the two potentials measured, and the latter the mean of the two. Finally, by graphical extrapolation of the values in column six to zero concentration of iodine, a value has been obtained for each cadmium iodide solution which would represent the concentration of iodine ion in the given cadmium iodide solution if it contained no dissolved iodine. These four extrapolated values are the important ones for our present purpose. Since all these iodine-ion concentrations are very low we can certainly afford to disregard here the slight error involved in the assumption that the results of electromotive force measurements represent concentrations rather than "activities" as defined by Lewis. (For a discussion of the relation between activity and concentration for the iodine ion in potassium iodide solutions, see Bray and MacKay, *Journ. Am. Chem. Soc.*, 1910, xxxii., 925).

Discussion.—In the previous investigation, as has already been stated, values were obtained for the proportion of simple molecules, ionised and non-ionised, in a pure solution of cadmium iodide at various concentrations. This quantity we shall designate, as in our former article, by the term "active fraction." The rest of the cadmium iodide must consist of associated cadmium iodide molecules, and of the ions, simple or complex, formed therefrom.

These values of the active fraction are calculated upon the assumption that the abnormally low power of cadmium iodide to unite with iodine is due entirely to the presence of complexes, a condition which may be only approximately fulfilled. The amount of iodine taken up by an iodide should be practically independent of its degree of ionisation, provided that the tri-iodide is ionised to about the same extent, as is no doubt generally the case. (This is confirmed by the fact that for all metallic iodides so far investigated, with the exception of those of cadmium and mercury, the value of the equilibrium constant $K_1 = (\Sigma I)(I_2)/(\Sigma I_3)$ is the same. The list includes the iodides of di- and trivalent metals, Ba, Sr, Zn, Ni, and La, whose degrees of ionisation are certainly somewhat different from those of the univalent iodides). But although it is contrary to experience that two metallic salts of like type, and as closely related as are cadmium iodide and cadmium tri-iodide should show any large difference in ionisation, the possibility of slight differences is not excluded, which, if present, would cause small positive or negative errors in the value of the active fraction, calculated as above.

According to McBain (*Zeit. Elektrochem.*, 1905, xi., 215) the observed transport numbers indicate that the complex ion present in predominating amount is CdI_3', formed by ionisation of $(CdI_2)_2$ according to the reaction:—

$$(CdI_2)_2 \rightleftharpoons 2CdI_3' + Cd^{++}.$$

Whether or not this inference is correct it is probable hat the above equilibrium is typical, and that the inactive raction consists essentially of—(*a*) associated molecules, *b*) complex anions, and (*c*) simple Cd^{++} cations. It ollows therefore that the degree of ionisation of the simple CdI_2 *molecules may be calculated, at least approximately,* y dividing the concentration of the iodine ion, taken from Table I., by the equivalent concentration of the "active" admium iodide as derived from the data of the previous nvestigation.

Table II. shows the results obtained in this way. The rst three columns contain the concentrations of total admium iodide, of active cadmium iodide, and of the dine ion, respectively. The fourth column gives the egree of ionisation of the simple CdI_2 molecules as calulated from columns two and three, and the fifth shows, or comparison, the degrees of ionisation of cadmium itrate, a normally ionised salt of like type at the same oncentrations as those of $(CdI_2)_{active}$ in column two. The data for cadmium nitrate were obtained by interolation from values given by Noyes and Falk (*Journ. Am. Chem. Soc.*, 1912, xxxiv., 475).

TABLE II.

(CdI_2).	$(CdI_2)_{active}$.	(I').	$\gamma=\frac{(I')}{2(CdI_2)_{active}}$.	γ for $Cd(NO_3)_2$ at 18°.
500	30·0	30·4	0·51	0·78
250	26·5	31·2	0·59	0·79
125	21·0	27·5	0·65	0·80
10	5·5	10·5	0·95	0·87

According to these results the degree of ionisation of the CdI_2 molecules is considerably lower, except in the most ilute solution, than that of the cadmium nitrate. A ifference in this direction, though smaller in amount, would be expected on account of the presence in the admium iodide solution of an excess of Cd^{++} ions reulting from the ionisation of the associated molecules, nd it would also be expected that the difference, if due o this cause, would decrease with increasing dilution, as s, in fact, the case. It is probable, however, that the ctual difference between the degrees of ionisation of hese two salts is considerably smaller than these results would indicate, for the error in determining γ by the above method may easily be rather large.

The work of Walton (*Zeit. Phys. Chem.*, 1904, xlvii., 85), whose kinetic method for determining iodine ion oncentrations has already been referred to, is of interest ere, since his results yield values of (I') which can be ompared with those in Table I. Unfortunately, Walton's xperiments with cadmium iodide were confined to soluions more dilute than 0·05 molar. The comparison is hown in Table III., the second horizontal line giving the alues of (I') calculated from Walton's results, while the hird contains our values for the same quantity. (These alues were obtained by dividing the observed velocity onstants in each case by 1·45, the average value of the atio *Velocity constant*/(I'), as found by Walton's experinents with KI, NaI, and NH_4I).

Figures enclosed in parentheses were obtained by raphical interpolation.

TABLE III.

(CdI_2).	4·9.	10.	19·4.	31·8.	42·1.
(I') Walton	6·5	(12)	19·3	26·3	31·2
(I') V. N. and B. ..		10·5	(14)		20

The two sets of results agree in order of magnitude, hough Walton's values are higher and increase more apidly with the concentration. Since Walton's method as not yet been very thoroughly studied, particularly as o its sensitiveness toward secondary catalytic influences, he results of the electromotive force measurements eserve the greater weight.

(To be continued).

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, March 7, 1918.

Sir J. J. THOMSON, O.M., President, in the Chair.

PAPERS were read as follows:—

"*Numerical Solution of Integral Equations.*" By Prof. E. T. WHITTAKER, F.R.S.

The present communication is concerned with integral equations of Abel's type—

$$\int_0^x \phi(s)K(x-s)ds = f(x),$$

and of Poisson's type—

$$\phi(x)+\int_0^x \phi(s)K(x-s)ds = f(x),$$

where $K(x)$ and $f(x)$ are given functions, and $\phi(x)$ is the unknown function which is to be determined. The object of the work is to obtain solutions of these equations in forms which can be made the basis of numerical calculation.

Theoretical solutions of both these equations are well known in the form of infinite series, the nth term of each series being a multiple integral involving $(n-1)$ integrations with variable limits; but from such series it is impracticable, except in very special cases, to compute the solution $\phi(x)$ numerically. In the present paper the author departs altogether from this method of solution, and obtains instead a solving function which can be expressed in a finite form in terms of known functions, when the function $K(x)$ is of a certain type, to which a tabulated function can in nearly all practical cases be reduced. As typical of the theorems in the paper the following may be given:—

The solution of the integral equation—

$$\int_0^x \phi(s)K(x-s)ds = f(x)$$

where—

$$K(x) = x^{-p}(a_0+a_1x+a_2x^2+\ldots+a_nx^n) \quad (0<p<1)$$

is—

$$\phi(x) = \frac{\sin p\pi}{\pi}\int_0^x f'(s)L(x-s)ds,$$

where—

$$L(x) = \frac{x^{p-1}}{a_0}+\frac{a^{n-p}}{F'(\alpha)}\gamma_p(\alpha x)+\frac{\beta^{n-p}}{F'(\beta)}\gamma_p(\beta x)+\ldots+\frac{\nu^{n-p}}{F'(\nu)}\gamma_p(\nu x)$$

and where $\alpha, \beta, \ldots \nu$ are the roots of the algebraic equation—

$$F(x) = a_0x^n+(1-p)a_1x^{n-1}+(1-p)(2-p)a_2x^{n-2}+\ldots(1-p)(2-p)\ldots(n-p)a_n = 0,$$

and $\gamma_p(x)$ denotes the incomplete γ-function—

$$\gamma_p(x) = e^x\int_0^x s^{p-1}e^{-s}ds.$$

"*Cesaro Convergence of Restricted Fourier Series.*" By Prof. W. H. YOUNG, F.R.S.

"*Non-harmonic Trigonometrical Series.*" By Prof. W. H. YOUNG, F.R.S.

"*Electromagnetic Inertia of the Lorentz Electron.*" By Prof. G. A. SCHOTT.

For a perfectly conducting oblate spheroid with speed kC, eccentricity k and axis in the direction of motion, G. W. Walker (*Roy. Soc. Proc.*, A, xciii., 448), finds—

Longitudinal electromagnetic mass =

$$= \tfrac{2}{3}e^2a^{-1}C^{-2}(\tfrac{1}{3}-k^2)(1-k^2)^{-3/2},$$

Transverse electromagnetic mass =

$$= \tfrac{1}{3}e^2a^{-1}C^{-2}(1+\tfrac{1}{15}k^2)(1-k^2)^{-1/2}.$$

Walker appears to regard this spheroid as a model of the Lorentz electron. If this be so, there is an obvious contradiction with the Theory of Relativity which demands investigation. The author has recalculated Walker's results on the basis of the general mass formulæ given in "Electromagnetic Radiation," Appendix D.

Walker's value of the longitudinal mass is obtained, provided that for accelerated rectilinear motion the electron retains the shape it has at time t for an infinitesimal interval instead afterwards instead of contracting continuously.

But a factor $(1+\frac{1}{10}k^2)$ *in place of Walker's factor* $(1+\frac{3}{5}k^2)$ *in the numerator of the transverse mass* is obtained on the supposition that for uniform circular motion the electron has its axis in the direction of motion at the time t, but moves without rotation for an infinitesimal interval afterwards instead of rotating continuously. It has not been possible to trace the outstanding discrepancy to its source. Nevertheless, the agreement between Walker's results and those of the paper, so far as it goes, indicates that his spheroid is not to be regarded as a model of the Lorentz electron. The *Lorentz expressions for the masses pre-suppose that the* electron continuously suffers the contraction and rotation appropriate to its change of motion at each instant.

"*Researches on Growth and Movement in Plants by means of the High Magnification Crescograph.*" By Sir J. C. BOSE.

FARADAY SOCIETY.

Ordinary General Meeting, February 14, 1918.

Prof. C. A. EDWARDS, D.Sc., of the University, Manchester, in the Chair.

GENERAL DISCUSSION ON "ELECTRIC FURNACES."

THE CHAIRMAN, in introducing the subject, gave a short account of the history of electric smelting since Siemens in 1878 patented his first small coke electric furnace. In 1904 there were only four electric furnaces in Europe and America; in 1913 there were 114. Development since the war has been phenomenal.

Mr. H. ETCHELLS, B.Met., M.Inst.Met., read a paper on "*Applications of Electric Furnace Methods to Industrial Processes.*"

The author referred to the growth of electric furnace industries during the war, which was due not only to the greater output demanded, but to a certain extent because the electric furnace enabled us to use raw materials which were formerly considered inferior for the quality of product desired.

In dividing electric furnaces under the three headings, *Induction*, *Resistance*, and *Arc* types, the author considered that only the latter two types may be looked to for future extensive development.

A plea was made for the greater development of the resistance furnace, which from the electric load viewpoint was ideal, giving high lode factor, high power factor, and very slight fluctuation. The Bailey furnaces were mentioned as the *only furnaces* of this type which had hitherto attained an industrial development in large units.

In briefly referring to the smelting of iron ores and ferro-alloys the author emphasised the *necessity for an ample* supply of cheap electrical energy, and drew attention to the prosperity of countries like France, North America, Norway, and Sweden, which were utilising their natural resources of water-power for generating a plentiful supply of cheap electric power.

The greatest development of electric furnaces it was pointed out had taken place in connection with the steel industry, and *especially in regard to the production of* special high quality steel castings. An illustration of specimen castings was shown, giving some idea of the intricate work which can be *undertaken with a considerable degree of accuracy.*

In the author's opinion the electric furnace is not fulfilling its highest function in the foundry when used for simply melting steel scrap to turn out an unrefined product on an acid lining.

The success attained by the Greaves-Etchells furnace in high-speed steels was specially indicated, some Sheffield firms having dispensed with the crucible process and adopted the electric process whole heartedly.

Views and diagrams of the Greaves-Etchells furnaces were shown, and it was remarked that in this country this type of furnace shared with the Héroult and Electro-Metals types the popularity of the market.

Typical wave-form diagrams of these three types of furnace were shown, and considerable emphasis was laid on the steadiness of load produced by the buffering effect of bottom electrode furnaces.

Attention was drawn to important sources of loss of power during transmission from transformers to interior of furnace, this being due to bad contact joints, skin resistance, and inductance.

The total economy of graphite electrodes was pointed out, and the value of sealing devices, such as economisers, which are fitted to Greaves-Etchells furnaces was strongly advocated.

The unsatisfactory performance of refractory lining materials at present marketed was commented upon, and the author stated it as his belief that satisfactory linings would not be available until electrically fused refractories were put on the market.

Mr. J. BIBBY, M.Sc., read a paper on "*Electric Steel Refining Furnaces.*"

The development of the electric furnace for steel making is *almost certain to take place in the direction of large* furnaces. As furnaces get larger new conditions appear, which require consideration in the design, but economies can be effected in consumption of current, refractory materials, and labour. On small furnaces, up to 5 tons capacity, two electrodes are sufficient, but on the larger furnaces it is advisable not to concentrate the heating zone in two places, but to distribute it by having four electrodes over a circular bath. Further, on large furnaces large currents are required, and up to the present we only have electrodes which will take currents of, say 10,000 ampères, so that where more than 20,000 ampères are required, more than two electrodes are required for this reason. In the use of four upper electrodes we are confronted with an electrical problem. It was explained in the paper that whatever system is adopted it must be such that when equal currents are flowing through each of the arcs, then equal currents must be taken from each of the three high-tension mains, and each of these three primary *currents must be practically in phase with its voltage in* order to secure a higher power factor. Further, for metallurgical reasons it is considered desirable that a certain amount of current should flow vertically through the hearth to a fifth fixed electrode beneath it. We therefore require some system which will impress an equal voltage between each upper electrode and the hearth electrode, so that when equally adjusted equal currents, and therefore four equal heating zones, will be obtained.

The condition is met if we can obtain on the furnace side of the transformers four equal phases, one for each *electrode, and a common return to a neutral electrode* beneath the hearth. In short, we require a 4-phase, 5-wire system. This can be obtained by simply having two sets of two phases working in parallel, but this system has serious electrical objections. The problem has been satisfactorily solved by the Electro-Metals 4-phase arrangement, which consists of three single-phase transformers. Two of these transformers have their terminals connected separately to the four upper electrodes. A tapping is taken from the middle of the third or Teaser transformer to the hearth electrode, and the terminals of the Teaser transformer *are connected to intermediate tappings on the main* transformers. A closed system is thus obtained when arc

are struck between the four upper electrodes and the bath of metal. This system gives an equal voltage in each of the arcs, and therefore equal heating zones, and also when the electrodes are regulated for equal currents, then equal currents are taken from the three primary mains. The average power factor of the system on a non-inductive load is unity. Further advantages of the system are that when the furnace is under poor regulation the primary currents remain tolerably balanced with a high power factor.

A paper on "*Electric Furnace Control*" was presented by Mr. A. P. M. Fleming and Mr. F. E. Hill.

An important feature of electric furnaces is that by suitable control the temperture can be accurately and quickly regulated. The paper sets forth the general principles on which such control is based in the case of furnaces using alternating currents.

The methods of control are classified as follows:—

I. *By Variation of Voltage.*

1. Alteration of the ratio of the main transformer by cutting out a portion of the primary winding.

2. Alteration of the ratio of the main transformer by an auxiliary winding which can be connected up in series with or in opposition to the main winding.

3. Use of a primary booster transformer to vary the secondary voltage by altering the pressure supplied to the primary.

4. Use of a secondary booster transformer, the secondary of which is in series with the main secondary, the booster primary being in parallel with the main primary.

5. Control by means of a motor-generator; a method rarely used.

These various methods of voltage control are discussed in detail, and compared as regards reliability and first cost. The necessary regulating switches are also described.

II. *By Variation of Current.*

Control by this method is accomplished by raising or lowering the electrodes. It may be employed as an auxiliary method to any of those previously described. Examples of both hand regulation and automatic regulation are given in the paper.

Discussion.

Mr. Donald F. Campbell drew attention to the great advances in electrometallurgy made in Great Britain since 1914. It was now possible to do without the large imports of Swedish iron and steel formerly required for high-class products. Further development would enable use to be made of our enormous deposits of phosphoric ores.

The efficiency of the electric steel furnace had almost reached its probable maximum, and its capacity was not likely to exceed 30 tons. Metallurgical considerations were more important in determining size than electrical or economic factors.

He urged closer co-operation between the consumer and the power engineer to effect further economies. More effective regulation of current supplied to batteries of furnaces was also necessary for the same end.

The value of water-power had been overestimated. Steam-power, with its comparatively low first cost, was more favourable for the average steel furnace with a low power factor.

Future developments in furnaces were to be sought principally in mechanical and electrical details. As regards the industry as a whole, a broader point of view, with a resulting reduction in cost of current on the part of the supply companies, and a wider appreciation on the part of metallurgists of the vast possibilities of intense electric heating, was essential to substantial progress. The British Empire should be able to provide all the special steels essential either for peace or war.

Mr. R. G. M. Mercer criticised some features in the general design and operation of electric furnaces. The open furnace doors at the bottom and the large electrode spaces at the top tended to increase electrode consumption, but certain economisers were now being used which effect a 20 to 30 per cent saving of electrodes.

Prof. W. G. Fearnsides thought that even in big furnaces the engineering design was in the laboratory stage, and an enormous strain was being put on the refractory materials.

Mr. Thomas Annis also dwelt on the failure of refractories.

Dr. J. Newbury said that at Newcastle power was being supplied at a cheaper rate than at Niagara.

Mr. J. Drummond Paton pointed out that 30 million tons of coal, a potential source of electrical energy, were being wasted annually.

Mr. J. S. Peck was of opinion that much work was still necessary on both control and design of furnaces.

Mr. Telford Petrie found the arc type most satisfactory for high-temperature work, in spite of troublesome control.

Mr. H. M. Ridge referred to a remarkable instance of the use of magnesite arches in some furnaces he had seen in Austria.

Mr. E. J. Stock referred to the low electrode consumption of the single-phase Snyder furnace, and also to the Miles-Walker balancing machine, by which ordinary supply mains could be tapped for use in single-phase furnaces.

The Chairman, in bringing the discussion to a close, said that as regards refractories, we were a long way from realising a substitute for silica for furnace roofs. The great quality of the electric furnace was the remarkable purity of the steel made in it.

PHYSICAL SOCIETY.

Ordinary Meeting, March 8, 1918.

Prof. C. H. Lees, F.R.S., President, in the Chair.

A paper on "*The Asymmetrical Distribution of Corpuscular Radiation Produced by X-rays*" was read by Mr. E. A. Owen. (Abstract).

1. The ratio of emergent to incident corpuscular radiation in the case of the two salts, potassium bromide and silver nitrate, has been investigated, when the exciting X-radiations were the characteristic radiations of copper, bromine, silver, and tin.

2. The ratio has the same value whether the salt is in the wet or in the dry state.

3. The value of the ratio was found to be approximately the same for each two of the salts, and is equal to 1·17. This is approximately the same figure as that found by other observers in the case of the metals, gold and silver.

Discussion.

Dr. D. Owen said the experimental results appeared to be conclusive, and the ratio obtained agreed surprisingly well with the values of other observers. It seemed to him that the preponderance of secondary radiation on the emergent side followed from any theory of X-radiation. On the ether pulse theory we have, in addition to the electromagnetic forces in the wave front, the momentum of the incident beam, which would tend to assist the emission in the direction of emergence and retard it in the reverse direction. Similar considerations apply to the continuous wave theory, while on the quantum theory the energy is concentrated in blows which fall on very small parts of the atoms, and might have quite sufficient momentum to dislodge electrons. He gave numerical figures to show that if the intensity of the beam was of the order of full sunlight, it would be sufficient to account for the emission of 10^{-15} β-particles per second per square centimetre of the screen.

Dr. H. S. Allen said that if he understood the paper rightly, the result that Mr. Owen has found—viz., that the ratio of emergent to incident corpuscular radiation is the

same in the amorphous as in the crystalline state, renders doubtful the explanation of asymmetry put forward by H. A. Wilson. In his opinion an explanation of a more fundamental character was required than that which attributes the asymmetry of the scattered radiation to the difference between the behaviour of crystalline and amorphous material. In this connection a recent paper by A. H. Compton (*Journ. Wash. Acad. Sci.*, January 4, 1918) is of considerable interest. He assumes that the electron is in the form of a spherical shell, each part of which can scatter independently, and may be capable of rotational motion. He shows that it is then possible to explain not only the asymmetry of the scattered rays, but also the diminution of scattering with decrease of wave-length. Since the mass of an electron cannot be accounted for on the basis of a uniform distribution of electricity over the surface of a sphere, Mr. Compton suggests that the true shape of the electron may be that of a ring, having an effective radius many times greater than that ordinarily accepted. Mr. Compton's estimate of the radius is $2{\cdot}3 \times 10^{-10}$ cm., but if some recent measurements by Sir Ernest Rutherford are used in the calculation, this estimate must be reduced to about one-tenth of the value stated (*Nature*, 1918, c., 510). If this hypothesis of a ring electron be accepted, the electron may act as a small magnet, as suggested by A. L. Parson, and this explains Forman's effect of magnetisation of iron upon its absorption coefficient.

Mr. T. SMITH thought the initial equation with which the paper started was somewhat extraordinary. It was difficult to see what physical considerations gave rise to the factor cost $\frac{1}{2}\theta$ in the denominator of an equation which he presumed was intended to apply from 0 to 180°.

The author, in reply, said that if the asymmetry is to be attributed to the pressure of radiation, one would expect that the value of the ratio obtained for the asymmetry would vary with the intensity of the exciting X-radiation. It has been shown, however, by Philpot that this is not the case, the value of the ratio remaining the same for radiations of the same wave-length whether a beam of X-rays direct from a bulb or a beam of characteristic rays from a metal plate were employed to excite the corpuscular radiation; the intensity of the radiation would be much greater in the former than in the latter case. The results of the present paper show that the explanation put forward by Wilson to explain the asymmetry in the case of X-radiation does not appear to be adequate to explain the asymmetry in the case of corpuscular radiation. He agreed with Dr. Allen that an explanation of a more fundamental character is necessary to account for this phenomenon.

A paper on "'*Air Standard' Internal Combustion Engine Cycles and their Efficiencies*," was read by the President, Prof. C. H. LEES, D.Sc., F.R.S. (Abstract).

It is well known that the efficiency of an air standard internal combustion engine working through a cycle bounded by two adiabatics, and either two isothermals, two constant volume lines, or two contant pressure lines is given by $1-(1/r)^{\gamma-1}$ where r is the compression ratio and γ is the ration of the two specific heats of air.

In the present paper it is shown that the efficiency is given by the same expression if the cycle is composed of two adiabatics and two curves $pv^{a}=A$, $pv^{a}=a$, where a has any positive or negative value and A and a are constants. Since a may be chosen so that any explosion curve may be followed as closely as desired by short lengths of a curves, a cycle can be drawn with the above efficiency and any prescribed explosion curve. The ratio of the efficiency of a cycle with prescribed explosion and exhaust curves to that of the cycle so drawn is shown to be the ratio of the two areas on the indicator diagram. The thermal efficiency of a cycle with prescribed explosion and exhaust curves is therefore readily found.

DISCUSSION.

Dr. D. OWEN asked what the ratio of the efficiencies of the actual and theoretical cycles was in practice.

Dr. H. S. ALLEN asked if it was not possible to generalise the result established in the paper, and to say that the expression for the efficiency held when the explosion curve is represented by $f(p, v) =$ constant, where $f(p, v)$ is any function of p and v, provided the equation for the exhaust curve is suitably chosen.

Prof. LEES, in reply, said the ratio of the actual cycle to the other was usually 0·9 to 0·95. Dr. Allen's suggestion was quite correct. He had aimed, however, at expressing the result in a form suitable for graphical calculation.

BRITISH ASSOCIATION OF CHEMISTS.

MR. E. W. SMITH, Chemical Adviser to the Birmingham Corporation Gas Department, presided at a recent meeting of the Birmingham Section of the British Association of Chemists, held at the University. The attendance was representative of research and industrial chemists. The Chairman stated that ten sections had been formed, and others were in process of formation. In view of this the Executive had decided that it would be more representative of the country as a whole if it were constituted of one member from each local section rather than of three members each from Manchester and Birmingham. This had been done, and was giving excellent results. In view of the negotiations with the Institute of Chemistry the National meeting had been postponed, and this had further strengthened the movement by facilitating the formation of local sections. Referring to the negotiations with the Council of the Institute of Chemistry he pointed out that the proposals outlined in the British Association of Chemists' Executive report of February 1 had been amplified as a result of a recent meeting with the Council of the Institute. The Council were prepared to drop some of the saving clauses, and the age limit of twenty-seven in the case of candidates presenting themselves before December 31, 1921, a point on which they were more than meeting the suggestions of the B.A.C. Executive. The Council of the Institute were not desirous of setting up within itself a self-governing sole registration authority for all chemists. They found that the only method which they could adopt was to increase the number of associates. The Institute was obviously desirous of looking after the interests of all chemists, and would in a short time undertake to form a register of lower-grade chemists after a satisfactory settlement had been arrived at with the B.A.C. In the near future it was hoped that the Council of the Institute of Chemistry and the Executive of the B.A.C. would publish a joint report to the whole of the chemists in the country.

Mr. FRED C. A. H. LANTSBERRY (Birmingham Small Arms Laboratory) moved a resolution welcoming the statement that the Council of the Institute of Chemistry was prepared to carry out the aims and objects of the proposed British Association of Chemists, and expressing the opinion that the proposed modifications in the qualifications for membership of the Institute of Chemistry agreed to between the Council of the Institute and the Executive of the B.A.C. would reasonably ensure the inclusion of all qualified chemists.

Dr. A. PARKER, who seconded, said it was desirable to group all chemists—academic and industrial—so as to avoid an unnecessary multiplication of societies.

Mr. J. R. JOHNSON expressed the opinion that the negotiations as amended appeared to favour the younger generation of chemists, because it was difficult for a man over forty years of age to produce certificated evidence of his qualifications.

Mr. L. P. WILSON said that apparently the Institute rejected the idea of becoming the sole registration authority, but were willing partially to do the work by increasing the number of associates. He did not consider it desirable to drop the age limit of twenty-seven years because a young man of not more than twenty-three years of age ought to be willing to qualify by examination.

Replying on the discussion, the Chairman stated that the Institute of Chemistry were at the present time admitting older men in responsible positions without examination. Further, they considered a pass degree, *plus experience, to be the equivalent of a degree with* honours. The Institute did not reject the idea of becoming the sole registration authority, but could not agree to setting up a separate self-governing authority within the Institute. It would have to become the sole registration authority for all qualified chemists if the ideas of the B.A.C. were carried into effect.

The resolution was unanimously adopted.

A vote of thanks was accorded to the members of the local committee for their services—The Chairman, Mr. Lantsberry (Secretary), R. H. O'Shaughnessy (Secretary of the Birmingham Midland Section of the Society of Chemical Industry), Dr. Parker, Messrs. Farrar, Herapath, King, Carter, Pinnock, and Rosed.

NOTICES OF BOOKS.

The Practice of Pharmacy. By JOSEPH P. REMINGTON, Ph.M., Phar.D., F.C.S. Assisted by E. FULLERTON COOK, P.D. Sixth Edition. Philadelphia and London: J. B. Lippincott Co. Pp. xxviii+1987. Price 35s. net.

THIS treatise is very well known to pharmacists and students of pharmacy in this country as well as in America, and it is unrivalled for its clear and complete directions for performing all the operations involved in *preparing drugs and dispensing. Lengthy descriptions of* medicinal substances, their properties, uses, and doses, are included, and it is inconceivable that there could be any information which the pharmacist might require and which is not to be found in the book. The latest edition, which contains *over* 800 illustrations, has increased enormously in size owing to the necessity for making many additions relating to new preparations and methods and to the general progress of pharmaceutical knowledge. New articles have been added on sterilisation, ampul filling, tablet making, &c., with many illustration and descriptions of new apparatus. The preparations of the British Pharmacopœia, when different from those of the United States Pharmacopœia, are also included in tabular form.

MISCELLANEOUS.

Relationship of the Elements of the Argon Group.—The accompanying table of the atomic weights of the above *elements, whilst showing their relationship as* multiple of one another on an ascending scale of atomic weights, is sufficiently close in the relationship of these multiplies to confirm a group relationship, diversity from the multiple, confirming the possibility of their origin as a *family in* that there is the well known degradation of radium to helium.

H	=	4	
			5·85
Ne	=	20·2	
			1·87
A	=	39·8	
			2·108
Kr	=	82·92	
			1·45
Xe	=	133·2	
			1·74
Ra	=	226·0	

—J. C. THOMLINSON, B.Sc.

Royal Institution.—The following are the lecture arrangements at the Royal Institution after Easter, at 3 o'clock in the afternoon:—Prof. John Joly, two lectures on "Scientific Signalling and Safety at Sea." Prof. Arthur Keith, Fullerian Professor of Physiology, five lectures on "British Anthropologists"—(1) Barrow-explorers; (2) Cave-hunters; (3) Craniologists; (4) Field-Anthropologists; (5) A Master of Method—Pitt-Rivers. Sir Henry Newbold, two lectures on "The Poetry of Thomas Hardy"—(1) The Dynasts; (2) The Shorter *Poems.* Lieut.-Col. C. S. Myers, two lectures on "Present-day Applications of Experimental Psychology." Sir Isambard Owen, two lectures on "Rheims Cathedral." Sir James Frazer, two lectures on—(1) "The Folk-lore of Bells"; (2) "The Prosecution and Punishment of Animals." Lieut.-Col. Sir Francis Younghusband, three lectures on "The Abode of Snow—its Appearance, Inhabitants, and History." Prof. Edwin H. Barton, two lectures on "Musical Instruments Scientifically Considered." Prof. H. F. Newall, two lectures on "Modern Investigation of the Sun's Surface." Dr. W. L. Courtney, two lectures on "Dramatic Realism." Prof. Charles J. Patten, three lectures on "Problems in Bird-migration." The Friday Evening Meetings will commence on April 12, when Prof. E. C. C. Baly will deliver a Discourse on "Absorption and Phosphorescence." Succeeding Discourses will probably be given by Major G. I. Taylor, Sir A. Daniel Hall, Sir George Greenhill, Prof. F. Gowland Hopkins, Prof. A. Barton Rendle, Sir Boverton Redwood, and other gentlemen.

Society of Public Analysts and other Analytical Chemists.—The next meeting of the Society will be held on Wednesday, April 3, at the Chemical Society's Rooms, Burlington House, Piccadilly, W., at 5 p.m. The following papers will be read:—"Determination of Phosphoric Acid in Bone and Blood Fertilisers," by W. Rest Mummery; "The Deterioration of Lime on Keeping," by S. Allinson Woodhead; "Dog Fish Liver Oil," by A. Chaston Chapman; "Volumetric Determination of Barium, and a Method of Separation of Barium and Strontium," by John Waddell.

Condensed Milk.—The Ministry of Food anticipates completing its arrangements for the distribution of condensed milk by the end of March, and in early April will make its first allotment to the trade. The retail prices at which such condensed milk will be sold are as follows:—

Full Cream	Sweetened	.. 14 ozs.	net,	1s. 2½d. per tin.
,,	Unsweetened	.. 12 ozs.	,,	1s. 0½d. ,,
,,	Evaporated	.. 16 ozs.	,,	1s. 1d. ,,
Machine Skimmed	Sweetened,	16 ozs.	gross,	1s. 1d. ,,

The Ministry has amended the terms of payment laid down in General Regulations for sale and distribution of Condensed Milk, namely, G.R. Form, Clause 3, has been amended to read—"Terms of sale shall be as usual, but not to exceed one month net." Clause 12 has been amended to read—"Terms of sale shall be as usual, but not to exceed one month net."—March 12, 1918.

TO comply with Regulation 8 (*b*) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production *of Munitions of War, or of substances required for the production* thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Chemist (Analytical and Metallurgical) with Works experience requires Post.—Address, P. B., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Metallurgical Chemist wanted by Sheffield firm to take charge of shift on 7-ton Heroult furnace. Must have first-class experience with Carbon and Alloy Steels.—Address, S. F., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted for the Laboratory of large Chemical Factory, well-trained and experienced Analysts. Accurate and systematic workers required.—Address, C. B., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, Junior Chemist, experienced in high-class Steel Melting, for Small Electric Steel Furnace. Applicants must state age, experience, and wages required, and apply to their nearest Employment Exchange, quoting No. A 4915. No person already on Government work will be engaged.

THE CHEMICAL NEWS

VOL. CXVII., No. 3045.

SPECIAL NOTICE TO SUBSCRIBERS.

WE regret to announce that the recent paper restrictions will compel us for a period, until we can secure our usual supply of paper, to publish the CHEMICAL NEWS fortnightly instead of weekly.

The price will not be altered, except as regards the subscription price, which, until further notice, will be calculated at £1 for fifty-two numbers, or *pro rata*.

Subscribers will please note that the respective expiration dates of their subscriptions will be extended accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their extended subscription periods.

The next issue (No. 3046) will be published on April 26th.

VOLUMETRIC DETERMINATION OF MANGANESE BY MEANS OF SODIUM ARSENITE.

By FRED IBBOTSON, B.SC., A R.C Sc.I.

POTASSIUM permanganate is not largely used for the titration of solutions of trivalent arsenic, because better results are obtained by the use of iodine. Bussy made use of it in 1847 (*Comptes Rendus*, xxiv., 774), and also Péan St. Gilles twelve years later (*Ann. Chim. Phys.*, lv., 385).

The uncertainty of the end-point of the reaction, due to the formation of brown manganic compounds, was pointed out by Lenssen (*Journ. Prakt. Chem.*, lxxviii., 193), and also by Kessler in 1863 (*Pogg. Ann.*, cxviii., 48). An improvement in the method was suggested in 1895 by Vanino (*Zeit. Anal. Chem.*, xxxiv., 426) which took the form of the addition of an excess of permanganate to a hot solution of the arsenite, followed by a "back" titration with hydrogen peroxide, and in 1901 Kübling (*Ber.*, xxxiv., 404) obtained satisfactory results by the direct titration of a hot solution of arsenious acid containing 25 per cent of sulphuric acid. The last contribution to this subject appears to be that of Moser and Perjatel in 1912 (*Monatsh. Chem.*, vii., 33), who recommend the titration of arsenious acid in a cold solution containing from 0·1 to 0·3 grm. of the trioxide, at a dilution of 50 to 200 cc., and in presence of 5 to 15 cc. of concentrated hydrochloric acid. The permanganate is added in drops to the solution, which is continuously shaken during the titration, until a rose colour is obtained which persists for two or three minutes.

Each of these methods, seldom employed, is directed towards the determination of arsenic, but the converse operation of the determination of manganese by means of a standard solution of sodium arsenite is largely practised, and particularly in the analysis of steels containing chromium. The conversion of the manganese of steels to permanganic acid is usually effected in a solution (obtained by dissolving the metal in dilute nitric acid), by means of sodium bismuthate or ammonium persulphate. In the former case the excess of the insoluble oxidant is removed by filtration, and in both cases the permanganic acid is determined by titration with a solution of ferrous ammonium sulphate, hydrogen peroxide, or sodium arsenite. These solutions are usually standardised by means of potassium permanganate, and under the conditions obtaining during the assay of the steel for manganese. The results are therefore reliable, and, in the case of the first two, are in close agreement with theory. The fact, however, that when sodium arsenite is used in the titration of permanganic acid containing free nitric acid the "oxygen exchange" is not quantitatively expressible by—

$$2Mn_2O_7 + 5As_2O_3 \longrightarrow 4MnO + 5As_2O_5$$

does not appear to be generally known, probably because of the method of standardisation employed in works practice. The following tests are therefore not without interest in this connection.

Solutions of potassium permanganate and of sodium arsenite were prepared and standardised, the former by means of sodium oxalate and the latter with iodine.

Table I. appended shows the results obtained by *delivering the permanganate into the arsenite*, the volume of the solution being in each case about 100 cc. before the titration.

TABLE I.

Cc. of nitric acid 1·20	Cc. of arsenite.	Cc. of permanganate.	Ratio.
	Strength of solutions, N/50.		
10	20	22·8	1·14
20	20	22·3	1·115
30	20	21·8	1·09
30	20	22·9	1·145
15	20	23·4	1·17
	Strength of solutions, N/20.		
10	20	22·1	1·105
10	20	23·6	1·18
20	20	21·2	1·06
20	20	22·8	1·14
	Strength of solutions, N/10.		
20	20	22·5	1·125
10	20	23·2	1·16

The inconstancy of the ratio of permanganate to arsenite was observed to be influenced by the differing rates at which the permanganate was delivered, the higher values resulting invariably from rapid titrations. It was evident therefore that in the converse titration still higher values would be obtained. These are appended in Table II.

TABLE II.

Cc. of nitric acid, 1·20.	Cc. of permanganate.	Cc. of arsenite.	Ratio.
	Strength of solutions, N/20.		
10	20·5	15·2	1·35
20	42·2	31·5	1·34
20	23·8	17·9	1·33
15	20·5	15·6	1·31
	Strength of solutions, N/50.		
15	48·7	36·5	1·33
5	25·1	18·9	1·33
20	24·4	18·3	1·33
10	24·4	18·1	1·35

From these results it appears that solutions of sodium arsenite have a reducing value approximately 33 per cent in excess of the true value, when added to solutions of permanganate acidified with nitric acid. This result is obviously due to the formation of manganic compounds, and is evidenced also by the colour of the solutions at the end of the titration in the second series of experiments

and by the development of colour during the titration in the case of the first series.

The constancy of the ratio of the volume of permanganate to that of arsenite in the second series points to the existence in the solution of a definite compound, and further work on this point might profitably be undertaken.

Metallurgical Department, University of Sheffield.

THE COMPLEXITY OF THE CHEMICAL ELEMENTS.*

By Prof FREDERICK SODDY, M.A., F.R.S.

(Continued from p. 149).

The Chemical Elements not necessarily Homogeneous.

I PASS now to the second and most novel sense in which the elements, or some of them at least, are complex. In their discovery of new radioactive elements M. and Mme. Curie used radioactivity as a method of chemical analysis precisely as Bunsen and Kirchoff, and later Sir William Crookes, used spectrum analysis to discover caesium and rubidium, and thallium. The new method yielded at once, from uranium minerals, three new radio-elements, radium, polonium, and actinium. According to the theory of Sir Ernest Rutherford and myself, these elements are intermediate members in a long sequence of changes of the parent element uranium. In a mineral the various members of the series must co-exist in equilibrium, provided none succeed in escaping from the mineral, in quantities inversely proportional to their respective rates of change, or directly proportional to their periods of average life. Radium changes sufficiently slowly to accumulate in small but ponderable quantity in a uranium mineral, and so it was shown to be a new member of the alkaline-earth family of elements, with atomic weight 226·0, occupying a vacant place in the Periodic Table. Polonium changes 4500 times more rapidly, and can only exist to the extent of a few hundredths of a milligrm. in a ton of uranium mineral. Actinium also, though its life period is still unknown, and very possibly is quite long, is scarce for another reason, that it is not in the main line of disintegration, but in a branch series which claims only a few per cent of the uranium atoms disintegrating. In spite of this, polonium and actinium have just as much right to be considered new elements probably as radium has. Polonium has great resemblances in chemical character both to bismuth and tellurium, but was separated from the first by Mme. Curie and from the second by Marckwald. In the position it occupies as the last member of the sulphur group, bismuth and tellurium are its neighbours in the Periodic Table. Actinium resembles the rare-earth elements, and more closely lanthanum, but an enrichment of the proportion of actinium from lanthanum has been effected by Giesel. The smallness of the quantities alone prevents their complete separation in the form of pure compounds as was done for radium.

The three gaseous members, the emanations of radium, actinium, and thorium, were put in their proper place in the Periodic Table almost as soon as radium was, for, being chemically inert gases, their characterisation was simple. They are the last members of the argon family, and the fact that there are three of about the same atomic weight was probably the first indication, although not clearly appreciated, that more than one chemical element could occupy the same place in the Periodic Table.

The extension of the three disintegration series proceeded apace; new members were being continually added, but no other new radio-elements—new, that is, in possessing a new chemical character—were discovered. The four longest lived to be added, radio-lead or radium-D, as it is now more precisely termed, and ionium in the uranium series, and mesothorium-I and radiothorium in the thorium series, could not be separated from other constituents always present in the minerals, radium-D from lead, ionium and radiothorium from thorium, and mesothorium-I from radium. An appreciable proportion of the radioactivity of a uranium mineral is due to radium-D and its products, and its separation would have been a valuable technical achievement, but, though many attempts have been made, this has never been accomplished, and, we know now, probably never will be.

Seven years ago it was the general opinion in the then comparatively undeveloped knowledge of the chemistry of the radio-elements that there was nothing especially remarkable in this. The chemist is familiar with many pairs or groups of elements, the separation of which is laborious and difficult, and the radio-chemist had not then fully appreciated the power of radioactive analysis in detecting a very slight change in the proportions of two elements, one or both of which were radioactive. The case is not at all like that of the rare-earth group of elements, for example, in which the equivalent or atomic weight is used as a guide to the progress of the separation. Here the total difference in the equivalent of the completely separated elements is only a very small percentage of the equivalent, and the separation must already have proceeded a long way before it can be ascertained.

Human nature plays its part in scientific advances, and the chemist is human like the rest. My own views on the matter developed with some speed when, in 1910, I came across a new case of this phenomenon. Trying to find out the chemical character of mesothorium-I, which had been kept secret for technical reasons, I found it to have precisely the same chemical character as radium, a discovery which was made in the same year by Marckwald, and actually first published by him. I delayed my publication some months to complete a very careful fractional crystallisation of the barium-radium-mesothorium-I chloride separated from thorianite. Although a great number of fractionations were performed, and the radium was enriched, with regard to the barium, several hundred times, the ratio between the radium and mesothorium I was, within the very small margin of error possible in careful radioactive measurements, not affected by the process. I felt justified in concluding from this case, and its analogy with the several other similar cases then known, that radium and mesothorium-I were non-separable by chemical processes, and had a chemical character not merely like but identical. It followed that some of the common elements might similarly be mixtures of chemically identical elements. In the cases cited, the non-separable pairs differ in atomic weight from 2 to 4 units. Hence the lack of any regular numerical relationships between the atomic weights would on this view follow naturally. (*Trans. Chem. Soc.*, 1911, xcix., 72). This idea was elaborated in the Chemical Society's Annual Report on Radioactivity for 1910, in the concluding section summing up the position at that time. This was I think the beginning of the conception of different elements identical chemically, which later came to be termed "isotopes," though it is sometimes attributed to K. Fajans, whose valuable contributions to radioactivity had not at that date commenced, and whose first contribution to this subject did not appear till 1913.

In the six or seven years that have elapsed the view has received complete vindication. Really three distinct lines of advance converged to a common conclusion, and, so far as is possible, these may be disentangled. First, there has been the exact chemical characterisation from the new point of view of every one of the members of the three disintegration series, with lives over one minute. Secondly, came the sweeping generalisations in the interpretation of the Periodic Law. Lastly, there has been the first beginnings of our experimental knowledge of atomic structure, which got beyond the electronic constituents and at the material atom itself.

In pursuance of the first, Alexander Fleck, at my

* A paper read before the Royal Institution, May 18, 1917.

request, commenced a careful systematic study of the chemical character of all the radio-elements known of which our knowledge was lacking or imperfect, to see which were and which were not separable from known chemical elements. Seldom can the results of so much long and laborious chemical work be expressed in so few words. Every one that it was possible to examine was found to be chemically identical either with some common element or with another of the new radio-elements. Of the more important characterisations, mesothorium-II was found to be non-separable from actinium, radium-A from polonium, the three B-members and radium-D from lead, the three C-members and radium-E from bismuth, actinium-D and thorium-D from thallium. These results naturally took some time to complete, and became known fairly widely to others working in the subject before they were published, through A. S. Russell, an old student, who was then carrying on his investigations in radio-activity in Manchester. Their interpretation constitutes the second line of advance.

Before that is considered, it may first be said that every case of chemical non-separability put forward has stood the test of time, and all the many skilled workers who have pitted their chemical skill against Nature in this quest have merely confirmed it. The evidence at the present day is too numerous and detailed to recount. It comes from sources, such as in the technical extraction of mesothorium from monazite, where one process is repeated a nearly endless number of times; from trials of a very great variety of methods, as, for example, in the investigations on radium-D and lead by Paneth and von Hevesy; it is drawn from totally new methods, as in the beautiful proof by the same authors of the electro-chemical identity of these two isotopes; it is at the basis of the use of radioactive elements as indicators for studying the properties of a common element, isotopic with it, at concentrations too feeble to be otherwise dealt with, and from large numbers of isolated observations, as well as prolonged systematic researches. One of the finest examples of the latter kind of work, the Austrian researches on ionium, will be dealt with later. The most recent, which appeared last month, is by T. W. Richards and N. F. Hall, who subjected lead from Australian carnotite, containing therefore radium-D, to over a thousand fractional crystallisations in the form of chloride, without appreciably altering the atomic weight or the β-activity. So that it may be safely stated that no one who has ever really tested this conclusion now doubts it, and after all they alone have a right to an opinion.

This statement of the non-separability by chemical methods of pairs of groups of elements suffers perhaps from being in a negative form. It looks too much like a mere negative result, a failure, but in reality it is one of the most sweeping positive generalisations that could be made. Ionium we say is non-separable from thorium, but every chemist knows thorium is readily separated from every other known element. Hence one now knows every detail of the chemistry of the vast majority of these new radio-elements by proxy, even when their life is to be measured in minutes or seconds, as completely as if they were obtainable, like thorium is, by the ton. The difference it makes can only be appreciated by those who have lived through earlier days, when, in some cases, dealing with the separation of radio-constituents from complex minerals, after every chemical separation one took the separated parts to the electroscope to find out where the desired constituent was.

As the evidence accumulated that we had to deal here with something new and fundamental, the question naturally arose whether the spectrum of isotopes would be the same. The spectrum is known, like the chemical character, to be an electronic rather than mass phenomenon, and it was to be expected that the identity should extend to the spectrum. The question has been tested very thoroughly by A. S. Russell and R. Rossi in this country, and by the Austrian workers at the Radium Institut of Vienna, for ionium and thorium, and by various workers for the various isotopes of lead. No certain difference has been found, and it may be concluded that the spectra of isotopes are identical. This identity probably extends to the X-ray spectra. Rutherford and Andrada having shown that the spectrum of the γ-rays of radium-B is identical with the X-rays spectrum of its isotope, lead.

The Periodic Law and Radioactive Change.

The second line of advance interprets the Periodic Law. It began in 1911 with the observation that the product of an α-ray change always occupied a place in the Periodic Table two places removed from the parent in the direction of diminishing mass, and that in subsequent changes where α-rays are not expelled the product frequently reverts in chemical character to that of the parent, though its atomic weight is reduced 4 units by the loss of the α particle, making the passage across the table curiously alternating. Thus the product of radium (Group II.) by an α-ray change is the emanation in the zero group, of ionium (Group IV.), radium, and so on, while, in the thorium series, thorium (Group IV.) produces by an α-ray change mesothorium-I (Group II.), which, in subsequent changes in which no α-ray are expelled, yields radio-thorium, back in Group IV. again. ("Chemistry of the Radio-Elements," p. 29, First Edition 1911). Nothing at that time could be said about β-ray changes. The products were for the most part very short-lived and imperfectly characterised chemically, and several lacunæ still existed in the series masking the simplicity of the process. But early in 1913 the whole scheme became clear, and was pointed out first by A. S. Russell, in a slightly imperfect form, independently by K. Fajans from electro-chemical evidence, and by myself, in full knowledge of Fleck's results, still for the most part unpublished, all within the same month of February. It was found that, making the assumption that uranium-X was in reality two successive products giving β-rays, a prediction Fajans and Göhring proved to be correct within a month, and a slight alteration in the order at the beginning of the uranium series, every α-ray change produced a shift of place as described, and every β-ray change a shift of one place in the opposite direction. Further and most significantly, when the successive members of the three disintegration series were put in the places in the table dictated by these two rules it was found that all the elements occupying the same place were those which had been found to be non-separable by chemical processes from one another, and from the element already occupying that place, if it was occupied, before the discovery of radioactivity. For this reason the term "isotope" was coined to express an element chemically non-separable from the other, the term signifying "the same place."

So arranged, the three series extended from uranium to thallium, and the ultimate product of each series occupied the place occupied by the element lead The ultimate products of thorium should, because six α-particles are expelled in the process, have an atomic weight 24 units less than the parent, or about 208. The main ultimate product of uranium, since eight α-particles are expelled in this case, should have the atomic weight 206. The atomic weight of ordinary lead is 207·2, which made it appear very likely that ordinary lead was a mixture of the two isotopes, derived from uranium and thorium. The prediction followed that lead, separated from a thorium mineral, should have an atomic weight about a unit higher, and that separated from uranium minerals about a unit lower, than the atomic weight of common lead, and in each case this has now been satisfactorily established.

The Atomic Weight of Lead from Radioactive Minerals.

It should be said that Boltwood and also Holmes had, from geological evidence, both decided definitely against

t being possible that lead was a product of thorium, because thorium minerals contain too little lead, in proportion to the thorium, to accord with their geological ages. Whereas, the conclusion that lead was the ultimate product of the uranium series had been thoroughly established by geological evidence, and has been the means, *in the hands of skilful investigators, of ascertaining* geological ages with a degree of precision not hitherto possible. Fortunately I was not deterred by the *non possumus*, for it looks as if everybody was right! An explanation of this paradox will later be attempted. In point of fact, there are exceedingly few thorium minerals that do not contain uranium, and since the rate of change of uranium is about 2·6 times that of thorium, one part of uranium is equal as a lead-producer to 2·6 parts of thorium. Thus Ceylon thorianite, one of the richest of thorium minerals, containing 60 to 70 per cent of ThO_2, may contain 10 to 20 and even 30 per cent of U_3O_8, and the lead from it may be expected to consist of very similar quantities of the two isotopes, to be in fact very similar to ordinary lead. I know of only one mineral which is suitable for this test. It was discovered at the same time as *thorianite*, and from the same locality—*Ceylon thorite*, a hydrated silicate containing some 57 per cent of thorium and 1 per cent of uranium only. In the original analysis no lead was recorded, but I found it contained 0·4 per cent, which, if it were derived from uranium only, would indicate a very hoary ancestry, comparable, indeed, with the period of average life of uranium itself. On the other hand, if (1) all the lead is of radioactive origin, (2) is stable, and (3) is derived from both constituents, as the generalisation being discussed indicated, this 0·4 per cent of lead should consist of 95·5 per cent of the thorium isotope and 4·5 per cent of the uranium isotope. Thorite thus offered an extremely favourable case for examination.

In preliminary experiments in conjunction with H. Hyman, in which only a grm. or less of the lead was available, the atomic weight was found relatively to ordinary lead to be perceptibly higher, and the difference, rather less than one-half per cent, was of the expected order.

I was so fortunate as to secure a lot of 30 kilos. of this unique mineral, which was first carefully sorted, piece by piece, from admixed thorianite and doubtful specimens. From the 20 kilos. of first grade thorite the lead was separated, purified, reduced to metal, and cast *in vacuo* into a cylinder, and its density determined together with that of a cylinder of common lead similarly purified and prepared. Sir Ernest Rutherford's theory of atomic structure, to be dealt with in the latter part of this discourse, and the whole of our knowledge as to what isotopes were, made it appear probable that their atomic volumes, like their chemical character and spectra, should be identical, and therefore that their density should be proportional to their atomic weight. The thorite lead proved to be 0·26 per cent denser than the common lead. Taking the figure 207·2 for the atomic weight of common lead, the calculated atomic weight of the specimen should be 207·74.

The two specimens of lead were fractionally distilled *in vacuo*, and a comparison of the atomic weights of the two middle fractions made by a development of one of Stas's methods. The lead was converted into nitrate in a quartz vessel, and then into chloride by a current of hydrogen chloride, in which it was heated at gradually increasing temperature to constant weight. Only single determinations have been done, and they gave the values 207·20 for ordinary lead and 207·694 for the thorite lead, figures that are in the ratio of 100 to 100·24. This therefore favoured the conclusion that the atomic volume of isotopes is constant.

At the request of Mr. Lawson, interned in Austria, and continuing his researches at the Radium Institut under Prof. Stefan Meyer, the first fraction of the distilled thorite lead was sent him, so that the work could be checked. He reports that Prof. Hönigschmid has carried through an atomic weight determination by the silver method, obtaining the value 207·77 ± 0·014, as the mean of eight determinations. Hence, the conclusion that the atomic weight of lead derived from thorite is higher than that of common lead has been put beyond reasonable doubt.

Practically simultaneously with the first announcement of these results for thorium lead a series of investigations were published on the atomic weight of lead from uranium minerals, by T. W. Richards and collaborators at Harvard, Maurice Curie in Paris, and Hönigschmid and collaborators in Vienna, which shows that the atomic weight is lower than that of ordinary lead. The lowest result hitherto obtained is 206·046, by Hönigschmid and Mlle. Horovitz for the lead from the very pure crystallised pitchblende from Morogoro (German East Africa), whilst Richards and Wadsworth obtained 206·085 for a carefully selected specimen of Norwegian cleveite. Numerous other results have been obtained, as, for example, 206·405 for lead from Joachimsthal pitchblende, 206·82 for lead from Ceylon thorianite, 207·08 for lead from monazite, the two latter being mixed uranium and thorium minerals. But the essential proportion between the two elements has not, unfortunately, been determined. Richards and Wadsworth have also examined the density of their uranium lead. In every case they have been able to confirm the conclusion that the atomic volume of isotopes is constant, the uranium lead being as much lighter as its atomic weight is smaller than common lead. Many careful investigations of the spectra of these varieties of lead show that the spectrum is absolutely the same so far as can be seen.

(To be continued).

ON THE LUBRICATING AND OTHER PROPERTIES OF THIN OILY FILMS.

By Lord RAYLEIGH, O.M., F.R.S.

THE experiments about to be described were undertaken to examine more particularly a fact well known in most households. A cup of tea, standing in a dry saucer, is apt to slip about in an awkward manner, for which a remedy is found in the introduction of a few drops of water, or tea, wetting the parts in contact. The explanation is not obvious, and I remember discussing the question with Kelvin many years ago, but with little progress.

It is true that a drop of liquid between two curved surfaces draws them together and so may increase the friction. If d be the distance between the plates at the edge of the film, T the capillary tension, and α the angle of contact, the whole force is (see, for example, Maxwell on "Capillarity," Collected Papers, ii., 571):—

$$\frac{2AT\cos\alpha}{d} + BT\sin\alpha.$$

A being the area of the film between the plates and B its circumference. If the fluid wets the plate, $\alpha = 0$ and we have simply $2AT/d$. For example, if $d = 6 \times 10^{-5}$ cm., equal to a wave-length of ordinary light, and T (as for water) be 74 dynes per cm., the force per sq. cm. is 25×10^5 dynes, a suction of $2\frac{1}{2}$ atmospheres. For the present purpose we may express d in terms of the radius of curvature (ρ) of one of the surfaces, the other being supposed flat, and the distance (x) from the centre to the edge of the film. In two dimensions $d = x^2/2\rho$, and A (per unit of length in the third dimension) $= 2x$, so that the force per unit of length is $8\rho T/x$, inversely as x. On the other hand, in the more important case of symmetry round the common normal $A = \pi x^2$, and the whole force is $4\pi\rho T$, *independent* of x, but increasing with the radius of curvature. For example, if $T = 74$ dynes per cm., and $\rho = 100$ cm., the force is 925 dynes, or the weight of about 1 grm. The radius of curvature (ρ) might, of course, be

much greater. There are circumstances where this force is of importance; but, as we shall see presently, it does not avail to explain the effects now under consideration.

My first experiments were very simple ones, with a slab of thick plate glass and a small glass bottle weighing about 4 oz. The diameter of the bottle is $4\frac{1}{2}$ cm., and the bottom is concave, bounded by a rim which is not ground, but makes a fairly good fit with the plate. The slab is placed upon a slope, and the subject of observation is the slipping of the bottle upon it. If we begin with surfaces washed and well rubbed with an ordinary cloth, or gone over with a recently wiped hand, we find that at a suitable inclination the conditions are uniform, the bottle starting slowly, and moving freely from every position. If now we breathe upon the slab, maintained in a fixed position, or upon the bottle, or upon both, we find that the bottle *sticks*, and requires very sensible forces to make it move down. A like result ensues when the contacts are thoroughly wetted with water instead of being merely damped. When, after damping with the breath, evaporation removes the moisture, almost complete recovery of the original slipperiness recurs.

In the slippery condition the surfaces, though apparently clean, are undoubtedly coated with an invisible greasy layer. If, after a thorough washing and rubbing under the tap, the surfaces are dried by evaporation after shaking off as much of the water as possible, they are found to be sticky as compared with the condition after wiping. A better experiment was made with substitution of a strip of thinner glass about 5 cm. wide for the thick slab. This was heated strongly by an alcohol flame, preferably with use of a blowpipe. At a certain angle of inclination the bottle was held everywhere, but on going over the surface with the fingers, not purposely greased, free movement ensued. As might have been expected, the clean surface is sticky as compared with one slightly greased; the difficulty so far is to explain the effect of moisture upon a surface already slightly greased. It was not surprising that the effect of alcohol was similar to that of water.

At this stage it was important to make sure that the stickiness due to water was not connected with the minuteness of the quantity in operation. Accordingly, a glass plate was mounted at a suitable angle in a dish filled with water. Upon this fully drowned surface the bottle stuck, the inclination being such that on the slightest greasing the motion became free. In another experiment the water in the dish was replaced by paraffin oil. There was decided stickiness as compared with surfaces slightly greasy.

The better to guard against the ordinary operation of surface tension, the weight of the bottle was increased by inclusion of mercury until it reached 20 oz., but without material modification of the effects observed. The moisture of the breath, or drowning in water whether clean or soapy, developed the same stickiness as before.

The next series of experiments was a little more elaborate. In order to obtain measures more readily, and to facilitate drowning of the contacts, the slab was used in the horizontal position, and the movable piece was pulled by a thread which started horizontally, and passing over a pulley carried a small pan into which weights could be placed. The pan itself weighed 1 oz. (28 grms.). Another change was the substitution for the bottle of a small carriage standing on glass legs terminating in 3 feet of hemispherical form and 5 mm. in diameter. The whole weight of the carriage, as loaded, was $7\frac{3}{4}$ oz. The object of the substitution was to eliminate any effects which might arise from the comparatively large area of approximate contact presented by the rim of the bottle, although in that case also the actual contacts would doubtless be only three in number and of very small area.

With $\frac{1}{2}$ oz. in pan and surfaces treated with the hand, the carriage would move within a second or two after being placed in position, but after four or five seconds' contact would stick. After a few minutes' contact it may require $1\frac{1}{2}$ oz. in pan to start it. When the slab is breathed upon it requires, even at first, $3\frac{1}{4}$ oz. in the pan to start the motion. As soon as the breath has evaporated, $\frac{1}{2}$ oz. in pan again suffices. When the weight of the pan is included, the forces are seen to be as 1 : 3. When the feet stand in a pool of water the stickiness is nearly the same as with the breath, and the substitution of soapy for clean water makes little difference.

In another day's experiment paraffin (lamp) oil was used. After handling, there was free motion with 1 oz. in pan. When the feet stood in the oil, from $2\frac{3}{4}$ to 3 oz. were needed in the pan. Most of the oil was next removed by rubbing with blotting-paper until the slab looked clean. At this stage $\frac{3}{4}$ oz. in pan sufficed to start the motion. On again wetting with oil 2 oz. sufficed instead of the $2\frac{3}{4}$ oz. required before. After another cleaning with blotting-paper $\frac{1}{2}$ oz. in pan sufficed. From these results it appears that the friction is greater with a large dose than with a minute quantity of the *same* oil, and this is what is hard to explain. When olive oil was substituted for the paraffin oil, the results were less strongly marked.

Similar experiments with a carriage standing on *brass* feet of about the same size and shape as the glass ones gave different results. It should, however, be noticed that the brass feet, though fairly polished, could not have been so smooth as the fire surfaces of the glass. The present carriage weighed (with its load) $6\frac{1}{2}$ oz., and on the well-handled glass slide moved with $\frac{1}{4}$ oz. in pan. When the slide was breathed upon, the motion was as free as, perhaps more free than, before. And when the feet stood in a pool of water there was equal freedom. A repetition gave confirmatory results. On another day paraffin oil was tried. At the beginning $\frac{1}{4}$ oz. in pan sufficed on the handled slab. With a pool of oil the carriage still moved with $\frac{1}{4}$ oz. in pan, but perhaps not quite so certainly. As the oil was removed with blotting-paper the motion became freer, and when the oil-film had visibly disappeared the $\frac{1}{4}$ oz. in pan could about be dispensed with. Doubtless a trace of oil remained. The blotting-paper was of course applied to the feet and legs of the carriage, as well as to the slab.

In attempting to interpret these results it is desirable to know what sort of thickness to attribute to the greasy films on handled surfaces. But this is not so easy a matter as when films are spread upon water. In an experiment made some years ago (*Phil. Mag.*, 1910, xix., 96; *Scientific Papers*, v., 538) I found that the mean thickness of the layer on a glass plate, heavily greased with fingers which had touched the hair, was about one-fifth of the wave-length of visible light, viz., about 10^{-4} mm. The thickness of the layer necessary to induce slipperiness must be a small fraction of this, possibly one tenth, but perhaps much less. We may compare this with the thickness of olive oil required to stop the camphor movements on water, which I found to be about 2×10^{-6} mm. (*Proc. Roy. Soc.*, 1890, xlvii., 364; *Scientific Papers*, iii., 349). It may well be that there is little difference in the quantities required for the two effects.

In view of the above estimate and of the probability that the point at which surface-tension begins to fall corresponds to a thickness of a single layer of molecules (*Phil. Mag.*, 1899, xlviii., 321; *Scientific Papers*, iv., 430), we see that the phenomena here in question probably lie outside the field of the usual theory of lubrication, where the layer of lubricant is assumed to be at least many molecules thick. We are rather in the region of incipient *seizing*, as is perhaps not surprising when we consider the smallness of the surfaces actually in contact. And as regards seizing there is difficulty in understanding why, when it actually occurs, rupture should ensue at another place rather than at the recently engaged surfaces.

It may perhaps be doubted whether the time is yet ripe for a full discussion of the behaviour of the thinnest films, but I will take this opportunity to put forward a few remarks. Two recent French writers, Devaux (a summary

o Devaux's work, dating from 1903 onwards, will be found in the *Revue Gén. d. Sciences* for Feb. 28, 1913) and Marcelin (*Ann. Phys.*, 1914, i., 19), who have made interesting contributions to the subject, accept my suggestion that the drop of tension in contaminated surfaces commences when the layer is one molecule thick; but Hardy (*Proc. Roy. Soc.*, A, 1913, lxxxviii., 319) points out a difficulty in the case of pure oleic acid, where it appears that the drop commences at a thickness of $1\cdot3\times10^{-6}$ mm., while the thickness of a molecule should be decidedly less. Many of Devaux's observations relate to the case where the quantity of oil exceeds that required for the formation of the mono-molecular layer, and he formulates a conclusion, not accepted by Marcelin, that the thickness of the layer depends upon the existence and dimensions of the globules into which most of the superfluous oil is collected, inasmuch as experiment proves that when a layer with fine globules exists beside a layer with large globules, the former always contracts at the expense of the latter. As to this, it may be worth notice that the tension T of the contaminated surface could not be expressed as a function merely of the volume of the drop and of the two other tensions, *viz.*, T_1 the tension of an air-oil surface and T_2 that of a water-oil surface. It would be necessary to introduce other quantities, such as gravity or molecular dimensions. I am still of the opinion formerly expressed that these complications are the result of *impurity* in the oil. If the oil were really homogeneous, Devaux's view would lead one to regard the continued existence of two sizes of globules on the same surface as impossible. What would there be to hinder the rapid growth of the smaller at the expense of the greater until equality was established? On the other hand, an impurity, present only in small proportion, would naturally experience more difficulty in finding its way about.

The importance of impurities in influencing the transformations of oil-films was insisted on long ago by Tomlinson (*Phil. Mag.*, 1863, xxvi., 187); and as regards olive oil, Miss Pockels showed that the behaviour of purified oil is quite different from that of the common oil. She quotes Richter (*Nature*, xlix., 488) as expressing the opinion that the tendency of oil to spread itself on water is only due to the free oleic acid contained in it, and that if it were possible to completely purify the oil from oleic acid it would not spread at all (*Nature*, 1894, l., 223). Some confusion arises from the different meanings attached to the word "spreading." I suppose no one disputes the rapid spreading upon a clean surface which results in the formation of the invisible mono-molecular layer. Miss Pockels calls this a solution current—a rather misleading term, which has tended to obscure the meaning of her really valuable work. It is the second kind of spreading in a thicker layer, resulting in more or less rapid subsequent transformations, which is attributed to the presence of oleic acid. Miss Pockels says:—"The Provence oil used in my experiment was shaken up twice with pure alcohol, and the rest (residue) of the latter being carefully removed, a drop of the oil was placed upon the freshly formed water-surface in a small dish by means of a brass wire previously cleaned by ignition. The oil did not really spread, but after a momentary centrifugal movement, during which several small drops were separated from it, it contracted itself in the middle of the surface, and a second drop deposited on the same vessel remained absolutely motionless." I have repeated this experiment, using oil which is believed to have come direct from Italy. A drop of this placed upon a clean water-surface at once drives dust to the boundary in forming the mono-molecular layer, and in addition flattens itself out into a disk of considerable size, which rapidly undergoes the transformations well described and figured by Devaux. The same oil, purified by means of alcohol on Miss Pockels' plan, behaves quite differently. The first spreading, driving dust to the boundary, takes place entirely as before. But the drop remains upon the water as a lens, and flattens itself out, if at all, only very slowly. Small admixtures of the original oil with the purified oil behave in an intermediate manner, flattening out slowly and allowing the beautiful transformations which follow to be observed at leisure.

Another point of importance does not appear to have been noticed. Water-surfaces on which purified olive oil stands in drops *still allow the camphor movements*. Very small fragments spin merrily, while larger ones by their slower movements testify to the presence of the oil. Perhaps this was the reason why in my experiments of 1890 I found the approximate, rather than the absolute, *stoppage of the movements to give the sharpest results*. The absolute stoppage, dependent upon the presence of impurity, might well be less defined.

If, after the deposition of a drop of purified oil, the surface be again dusted over with sulphur or talc and then touched with a very small quantity of the original oil, the dust is driven away a second time and camphor movements ceased.

The manner in which impurity operates in these phenomena merits close attention. It seems pretty clear that from pure oil water will only take a layer one molecule thick. But when oleic acid is available a further drop of tension ensues. The question arises how does this oleic acid distribute itself? Is it in substitution for the molecules of oil, or an addition to them constituting a second layer? The latter seems the more probable. Again, how does the impurity act when it leads the general mass into the unstable flattened-out form? In considering such questions Laplace's theory is of little service, its fundamental postulate of forces operating over distances large in comparison with molecular dimensions being plainly violated.—*Philosophical Magazine*, xxxv., No. 206.

IONISATION AND POLYMERISATION IN CADMIUM IODIDE SOLUTIONS.*

By R. G. VAN NAME and W. G. BROWN.

(Concluded from p. 152).

Freezing-point Measurements.

SINCE the purpose of these measurements was to determine the effect of successive additions of iodine upon the freezing point of a given cadmium iodide solution, it was necessary to employ a method of the "undercooling" type, the very convenient and accurate method of Roloff (*Zeit. Phys. Chem.*, 1895, xviii., 572), as improved by Richards (*Journ. Am. Chem. Soc.*, 1903, xxv., 291), being excluded by the fact that it would not permit the concentration of the cadmium iodide to be kept constant. After unsuccessful attempts to obtain sufficient accuracy with the aid of a modified Beckmann apparatus, using a cryohydric mixture for the cooling bath, and other special precautions, an apparatus was finally devised which satisfactorily met the needs of the case. The construction and manipulation of this apparatus have been fully described in a former paper (*Am. Journ. Sci.*, 1917, [4], xliii., 110), so that only the principal points in the procedure need be given here.

The different cadmium iodide solutions used were kept in thoroughly steamed bottles of Jena glass. The freezing-point of the water was first taken. The water was then replaced by the cadmium iodide solution, which had been prepared by dissolving the carefully dried and weighed salt in a portion of the same water, and diluting to an exact volume. At least three determinations of the freezing-point were made, using varying degrees of undercooling, and no result was accepted unless the final temperature held constant within 0·001° (the maximum sensitiveness of the temperature reading) for at least five minutes. The volume of solution used in the freezing-point apparatus was either 200 or 250 cc.

* From the *American Journal of Science*, xliv., p 453

The pure cadmium iodide solution was next replaced by a portion of the same solution which had been shaken at room temperature with an excess of iodine in a Jena glass bottle for some hours. At 0° this solution was supersaturated with iodine. To ensure equilibrium with both ice and solid iodine the liquid was allowed to partially freeze, and was then kept at its freezing-point with continual stirring for several hours. Equilibrium was assumed to have been reached when successive determinations of the freezing-point agreed, and also successive titrations of the dissolved iodine. In this way the freezing-points were obtained for solutions saturated with iodine, and for those containing no dissolved iodine. Data for the intermediate iodine concentrations were obtained by mixing varying amounts of the saturated solution with the original pure cadmium iodide solution, determining the freezing-point as before, and finally estimating the iodine by titration.

In all these measurements care was taken to maintain the room temperature as constant as possible, and in a few cases where appreciable variation occurred the thermometer readings were corrected for change in the length of the projecting mercury thread with the aid of the usual formula, using the value 0·000156 for the apparent expansion coefficient for mercury in glass. This correction was applied only in working with the more dilute solutions where its importance was obviously greatest.

The results of these experiments are given in Table IV. The four concentrations of cadmium iodide studied are the same as in the measurements of electromotive force at 25°. Iodine concentrations are given in the second column, the starred values being those for solutions approximately saturated *with iodine, having iodine present as a solid* phase. In the third column are the observed freezing-point depressions, which in nearly every case are the mean of two or three separate determinations. The fourth and fifth columns contain the observed values, for the pure cadmium iodide solution, of the van 't Hoff coefficient i, and of the apparent degree of ionisation γ, as calculated in the ordinary way from i.

TABLE IV.

(CdI_2).	Dissolved iodine.	F. p. dep.	i = van 't Hoff coeff.	$\gamma = \frac{i-1}{2}$ Per cent	Dep. due to iodine.	Molec. dep. for iodine.
500	0·0	1·067°	1·147	7·35		
500	9·4	1·089			0·022°	2·34 (?)
500	19·6	1·095			0·028	1·43
500	27·9	1·112			0·045	1·61
500	*40·4	1·125			0·058	1·44
250	0·0	0·533°	1·145	7·25		
250	9·33	0·546			0·013°	1·40
250	19·4	0·558			0·025	1·29
250	24·9	0·567			0·034	1·37
250	*33·6	0·579			0·046	1·37
125	0·0	0·277°	1·193	9·65		
125	5·93	0·285			0·008°	1·35
125	10·29	0·293			0·016	1·56
125	16·75	0·301			0·024	1·43
125	*27·5	0·317			0·040	1·46
10	0·0	0·0365°	1·962	48·1		
10	2·344	0·0394			0·0029°	1·24
10	4·266	0·0424			0·0059	1·38
10	*7·53	0·0453			0·0088	1·17

Previous determinations of i for cadmium iodide by the freezing-point method have been made by Arrhenius (*Zeit. Phys. Chem.*, 1888, ii., 491), by H. C. Jones (*Zeit. Phys. Chem.*, 1893, xi., 544), and by Chambers and Frazer (*Am. Chem. Journ.*, 1900, xxiii., 512). Our values at the two lowest concentrations are in excellent agreement with those of Jones (whose results only cover concentrations up to 0·1 molar), and at the two higher concentrations they are close to the mean between the results of Arrhenius and those of Chambers and Frazer. No explanation is offered for the fact that i is slightly larger in 0·5 molar cadmium iodide than in the 0·25 molar solution, but the effect is real as it is even more evident in the results of the other investigators than in our own. Chambers and Frazer ascribe the phenomenon to hydration.

The last column of Table V. shows the "molecular depression for iodine" as obtained by dividing the depression due to iodine (column six) by its total concentration as given in column two. This quantity proves to be roughly constant irrespective of the concentration, and to have a value between 1·3 and 1·4, or about three-fourths of 1·86, the normal molecular lowering for a non-electrolyte in pure water.

The relatively large amount of this increase proves that the cadmium tri-iodide formed is derived ultimately from some source which previously contributed a much smaller number of molecules and ions to the solution. Unless, therefore, we are willing to admit that the cadmium tri-iodide may have in the solution a degree of ionisation many times greater than that of the simple cadmium iodide molecules, these results must be regarded as clear proof of the existence of complexes in these solutions. (A rough calculation shows that to account for the results in the absence of complexes the ratio of these two degrees of ionisation would have to be over 2 in the 0·01 molar solution, about 8 in the next, and about 25 in the strongest). On the other hand, if the effect is largely or wholly due to complexes, as is probably the case, the relative constancy of the values in the last column of Table IV. is an indication that the complexes are present in considerable quantity even in the more dilute solutions. On account of the low solubility of iodine in water at 0° the depression due to the iodine which remains uncombined is so small as not to affect the validity of this reasoning. (Its maximum value is 0·0012, which is reached only when the solution is saturated with iodine).

Owing to the presence of complexes it is of course impossible to get any accurate measure of the concentration of the iodine ion from the value of i, but in the present case the error so involved would not necessarily be very large. Of the various kinds of complex ions to be expected here the two simplest and most probable are CdI_3' and CdI_4'', formed as products of the equilibria—

$$2CdI_2 \rightleftarrows (CdI_2)_2 \rightleftarrows Cd^{++} + CdI_4''$$

and—

$$3CdI_2 \rightleftarrows (CdI_2)_3 \rightleftarrows Cd^{++} + 2CdI_3'.$$

In both of these cases the number of ions produced is the same as the number of CdI_2 molecules disappearing, so that the net result of the complex formation will be to diminish the freezing-point depression by a small amount due to that part which remains in the form of non-ionised polymerised molecules, $(CdI_2)_2$ or $(CdI_2)_3$ as the case may be. Hence, if values for the concentrations of the iodine ion are calculated in the usual way from the freezing-point lowerings the results will, in general, be low, but in sufficiently dilute solutions should not be very far from the truth.

In Table V. the iodine ion concentrations, so calculated, are tabulated for comparison with those derived from the measurements of electromotive force. For the two lowest concentrations the agreement is fairly good, but in the 0·25 molar solution the difference is not in the expected direction, and in the strongest solution the discrepancy is surprisingly large, far exceeding the probable experimental error. For this result there is no evident explanation, but it is significant that it coincides with a marked irregularity in the freezing-point lowering. As was noted above, the results of all cryoscopic measurements with cadmium iodide show that above about 0·3 molar the value of i apparently rises with the concentration, although the attendant decrease in ionisation and increase in polymerisation would both tend to lower it.

TABLE V.

(CdI_2).	(I') at 0° from freezing point.	(I') at 25° from E.M.F.
500	74	30·4
250	36	31·2
125	24	27·5
10	9·6	10·5

Nature and Concentration of the Complexes.—Thus far the question of the nature of the complex ions and molecules has been left open. Of the various complex ions which may be present in the solutions, CdI_3', as McBain has shown (*loc. cit.*), is apparently the most probable one. The high transport number of the anion, which approaches 1·25 in the most concentrated solutions, cannot be explained by assuming the predominance of CdI_4'' without assigning to that ion an improbably high velocity. This objection, however, would not apply to such ions as Cd_2I_5' or Cd_3I_8'', though there would be less reason to expect their presence than that of the less complex ones just mentioned.

McBain has calculated the approximate composition of a 0·1 molar solution of cadmium iodide upon the assumption that CdI_3' is the only complex ion present in appreciable amount. This calculation, which is based entirely upon freezing-point, transference, and conductivity data, gives the values (CdI_3') = 0·0084 and (I') = 0·0126. This would make (Cd^{++}) = 0·0105, thus accounting for about 19 per cent of the total iodide. McBain concludes that the remaining four-fifths is present in the form of simple non-ionised CdI_2 molecules, and that the proportion of complex molecules is negligible.

There are several serious objections to these figures:—(*a*) If so large a part of the salt is in the form of simple CdI_2 molecules the power of the salt to combine with iodine should be but slightly lower than normal, while in reality the "active fraction" at this concentration is only about 20 per cent. (This low power to unite with iodine cannot be explained by the low ionisation of the CdI_2 molecules unless it is assumed that the degree of ionisation of the cadmium tri-iodide is about nine times larger. This is obviously very improbable). (*b*) The molecular conductivity of the solution as calculated for 18° from the above composition is 22·5, or less than half the value actually measured, which is 46·7. (For the method of calculation see below. The ionic conductivities here used were those employed by McBain, namely, ½Cd = 51, CdI_3' = 41, and I' = 66·4. If the values given below be employed the result is 21·1 instead of 22·5). (*c*) The value of (I') calculated by McBain is much lower than that given by the electromotive force method.

In a similar manner it is possible to calculate the approximate composition of cadmium iodide solutions from the experimental data furnished by our measurements of electromotive force, and by our previous study of the iodine-cadmium iodide equilibrium. These calculations will be confined to the 0·01 and 0·125 molar solutions, for which the data are presumably most accurate. It will be assumed that CdI_3' is the only complex ion present in significant amount, and that the degree of ionisation of $(CdI_2)_3$ is of about the same order of magnitude as that of the average uni-bivalent electrolyte.

Allowing for the effect of the excess of Cd^{++} ions, which is much larger in the 0·01 molar than in the 0·125 molar solution, we may assume that the degree of ionisation is 80 per cent in the former and 75 per cent in the latter. An error of a few per cent in the degree of ionisation assumed will not greatly change the results. Using these degrees of ionisation, the "active fractions" given on p. 149 and the values of (I') from Table I., we obtain the results recorded in Table VI. That these values differ greatly from those of McBain is evident. Interpolation of these results for 0·1 molar concentration gives, approximately, (CdI_3') = 0·045 and (I') = 0·021, figures which are respectively 5 and 1·7 times those of McBain.

Since the values in Table VI. depend upon neither freezing-point nor conductivity measurements, their correctness may properly be tested by calculating the van 't Hoff coefficient *i* and the molecular conductivity for each solution. For *i* we obtain 0·0199/0·01 = 1·90, and 0·135/0·125 = 1·08 respectively, while the measured values (see Table V.) are 1·96 and 1·19.

TABLE VI.

	0·01 molar.	0·125 molar.
(CdI_3')	2·4	52·0
(Cd^{++})	6·45	39·7
(I')	10·5	27·5
(CdI_2)	0·25	7·2
$(CdI_2)_3$	0·3	8·6

To calculate the molecular conductivity we must obtain a value for the conductivity of CdI_3'. If we assume with McBain that the value 1·25, the limit which the observed (anion) transport number of a cadmium iodide solution tends to approach with increasing concentration, is that of the anion CdI_3', then the relative velocity of this ion must be $\frac{1 \cdot 25}{3} = 0 \cdot 42$; that is, $\frac{42}{58}$ that of Cd^{++}. For the equivalent conductivity of the Cd^{++} ion we may use the value 47 for 18°, which corresponds to 56 at 25°. This gives, for CdI_3', 34 at 18° and 40·5 at 25°. For iodine ion the values are 66·6 and 76·5 respectively. The molecular conductivity of the 0·01 molar solution at 25° should therefore be—

$$\{(0{\cdot}00645)(112) + (0{\cdot}0024)(40{\cdot}5) + (0{\cdot}0105)(76{\cdot}5)\} \div 0{\cdot}01 = 162{\cdot}2,$$

and for the 0·125 molar solution, calculated in the same way, 69·2.

These calculated conductivities are much too high, the measured values being 120 and 57 respectively, a result which seems to be due to some fault in the assumptions made rather than to experimental errors. It is not clear, however, how this discrepancy can be eliminated without introducing some other one. The evidence at hand is in some respects conflicting, and is obviously insufficient for an exact solution of the problem. In short, though some of the values in Table VI. are probably nearly correct, the figures as a whole can represent, at best, no more than a rough approximation to the truth.

The Iodine-Cadmium Iodide Equilibrium at 0°.—Each of the starred values in Table V. represents the solubility of iodine in the given solution at its freezing-point, which, as an approximation, may be assumed to be the same as the solubility at 0° in the same medium. By subtracting the solubility of iodine in pure water at 0° (0·000638 mols/litre) (Jones and Hartmann, *Journ. Am. Chem. Soc.*, 1915, xxxvii., 256) we obtain (ΣI_3), the equivalent concentration of the tri-iodide formed, and can therefore calculate the approximate value of the equilibrium constant $K_1 = (\Sigma I)(I_2)/(\Sigma I_3)$.

The results so obtained are given in Table VII., which compares the values of K_1 for cadmium iodide at 0° and 25° with those for potassium iodide at the same temperatures and concentrations. All of these figures refer to solutions saturated with iodine. The values for cadmium iodide at 25° were taken from our previous article; those for potassium iodide at 0° were calculated in the way just described from data given by Jones and Hartmann (*loc. cit.*, p. 250); those for potassium iodide at 25° were taken from the article of Bray and MacKay.

TABLE VII.

Concentration, equiv./litre.	Cadmium iodide—		Potassium iodide—	
	K_1 at 0° (approximate).	K_1 at 25°.	K_1 at 0°, Jones and Hartmann.	K_1 at 25°, Bray and MacKay.
1·0	0·0154	0·0234	—	0·00046
0·5	0·0090	0·0137	—	0·00088
0·25	0·0053	0·0082	—	—
0·10	—	—	0·000646	0·00131
0·03	0·0011	0·00247	0·000796	0·00137

These figures show that the values of K_1 for cadmium iodide at 0° is abnormal in the same way as at 25°, being larger throughout than for a normal iodide like potassium iodide, and increasing rapidly with the concentration. The effect upon K_1 of a change in temperature, however, is practically the same for the cadmium as for the potassium salt.

Summary.

1. Measurements have been made—(*a*) by the electromotive force method, of the iodine ion concentration in cadmium iodide solutions of 0·5, 0·25, 0·125, and 0·01 molar strength, containing various amounts of dissolved iodine; also (*b*) of the freezing-point lowering of each of these cadmium iodide solutions, and of the further lowering produced by the addition of known amounts of iodine.

2. Values of (I′) calculated in the ordinary way from the cryoscopic measurements should be slightly lower, if complexes are present, than those electrically measured. This was found to be the case in the 0·01 and 0·125 molar solutions, but not in the two stronger solutions.

3. The freezing-point of a cadmium iodide solution was depressed by the addition of iodine in a nearly constant ratio, which in the stronger solutions was about 1·4° per mol. and only slightly smaller in the weakest solution. This indicates the presence of complexes in considerable quantity even in the 0·01 molar solution. Neither this result nor the abnormally low power of cadmium iodide to unite with iodine can be accounted for, in the absence of complexes, by the assumption that the degree of ionisation of the cadmium iodide is very small, unless this low ionisation is accompanied by high ionisation of the cadmium tri-iodide, a state of affairs which is decidedly improbable.

4. A tentative calculation of the composition of the two more dilute cadmium iodide solutions, based upon the assumption that the ion CdI_3' and its parent molecule $(CdI_2)_3$ are the only complexes present, failed to give results in quantitative agreement with other experimental data.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, March 14, 1918.

Sir J. J. Thomson, O.M., President, in the Chair.

Papers were read as follows:—

"*On an Expansion of the Point-Potential.*" By. A. W. Conway, F.R.S.

The general solution of the equation $C^2\Delta^2\psi = \ddot{\psi}$ which is infinite at the origin, is of the form $f(Ct \pm r)/r$. This is infinite to the first degree. Referred to a different origin, a known expansion gives the series $\Sigma Y_n U_n$ where Y_n is a spherical harmonic and U_n is a certain function of t and of the distance to the new origin. This is a generalisation of the Legendre expansion of the inverse distance. In the paper the potential scale or vector of a moving point-charge is expanded in a similar series of spherical harmonics, the only restriction on the motions of the point-charge and of the origin being that the speed of the former must be less than that of light.

"*The Lunar and Solar Diurnal Variations of Water Level in a Well at Kew Observatory, Richmond.*" By E. G. Bilham.

The mean solar and lunar diurnal inequalities have been computed from two-hourly measurements of the Kew Observatory water-level records over a period of two years. Results are given for each month, for the year, and for groups of months representing high, intermediate, and low levels. Both the lunar and solar diurnal ranges are found to be largely dependent on the level of the water, *high levels being associated with large diurnal range*. In a paper recently communicated to the Society it was shown that a similar relation exists between the mean level and the sensitiveness to the effects of barometric pressure.

There are well-marked lunar and solar semi-diurnal oscillations throughout the year, the amplitude varying with the level in a manner similar to the diurnal range. In both cases the phase also varies with the level, the effect being most pronounced in the lunar results. The times of occurrence of the maxima become later as the water-level falls.

In comparison with the total oscillations in the neighbouring River Thames the well shows larger solar diurnal movements than were to be anticipated from the magnitude of the lunar oscillations. If, however, allowance is made for the effects of the solar diurnal variation of barometric pressure, the residual effects attributed to the solar tides are of the expected order of magnitude.

CHEMICAL SOCIETY.

Ordinary Meeting, March 7, 1918.

Prof. W. J. Pope, C.B.E., F.R.S., President, in the Chair.

The President referred to the loss sustained by the Society, through death, of the following Fellows:—Arthur Clegg Bowdler, Egerton Hargreaves, and Edmund Arthur Letts.

Messrs. G. Taylor, J. R. Morgan, T. W. Kirkwood, and G. Warburton were formally admitted Fellows of the Chemical Society.

The names of the Fellows recommended by the Council for election as Officers and as Ordinary Members of Council for 1918—1919 were read from the Chair.

The President announced that owing to the need for economy in the use of paper, the Council had decided not to provide each Fellow with a copy of the Report of Council, but that any Fellow wishing to consult the Report could do so by applying to the Assistant Secretary.

Certificates were read for the first time in favour of George Edwin Anderson, B.Sc., 247, John Williamson Street, South Shields; James Booth, 18, Wilfred Street, Derby; Stanley Dixon, M.Sc., 17, Morton Terrace, Gainsborough; Arthur Geake, M.Sc., No. 1, Staff House, Eastriggs, Dumfriesshire; William Hughes, 63, Goldington Avenue, Bedford; Stewart Roy Illingworth, B.Sc., A.R.C.S., Fern Villa, Chesham Bois, Chesham; George Johnson, 4, Birch Grove, Weaste, Manchester; Robert Duncan Masson, 13, Westbourne Grove, West Kirby, Birkenhead; Harold Scragg, Post Office, St. Anthony's, Newcastle-upon-Tyne; David Dryden Spence, Risca, Woodbine Avenue, Gosfort, Newcastle-upon-Tyne; William Edwin Upton, M.A., 663, Leigh Road, Leigh; Thomas Wallace, M.Sc., 307, Beaconsfield Street, Newcastle-upon-Tyne; Henry Worth, 70, Vyner Street, York.

A certificate for election has been authorised by the Council for presentation to ballot under By-law I. (3) in favour of Govindra Chandra Das, B.Sc., 20, Sunker Ghose Lane, Calcutta.

The following papers were read:—

"Atomic and Molecular Numbers." By H. S. Allen.

"The Alkaloids of Ipecacuanha." (Part III.). By F. L. Pyman.

Ordinary Meeting, March 21, 1918.

The President referred to the loss sustained by the Society, through death on February 22, 1918, of Mr.

Thomas Charles Cloud, who was elected a Fellow on February 7, 1878.

Certificates were read for the first time in favour of Wilfred John Brizell, 20, Cromer Drive, Wallasey, Cheshire; James Scott Dick, B.Sc., 93, Wellmeadow Road, Catford, S.E. 6; John Henry Freeman, 2, Park Road, Stanford-le-Hope, Essex; Archibald Edwin Goddard, B.Sc., "The Osborne," Irvine; Robert John Hughes, B.Sc., Lakefield House, Llanelly; Harold Thomas Islip, A.I.C., "Stilton," St. Mark's Road, Maidenhead; George Turpin Moore, B.Sc., 19, Neale Street, Roker, Sunderland; George Newbery, B.Sc., A.R.C.S., "Glenmore," Balcombe, Haywards Heath; William Charles Peck, 20, Bassano Street, East Dulwich, S.E. 22; Arthur Nutter Smith, 47, North Road, West Bridgford, Nottingham; John Henry Taylor, 56, Highbury, Newcastle-upon-Tyne; Thomas Tucker, 2, York Villas, Queen's Road, Buckhurst Hill, Essex; Augustus James Tyrrell, 11, Holdenhurst Road, Bournemouth; Arthur Robert Warnes, 47, Cranbrook Avenue, Cottingham Road, Hull.

LONDON CHAMBER OF COMMERCE.

"Bill to Amend the Patents and Designs Act, 1907."
"Bill to Amend the Trades Marks Act, 1905.

The President of the Board of Trade, the Right Hon. Sir A. Stanley, M.P., with the Parliamentary Secretary of the Board of Trade, Mr. Wardle, M.P., and the Comptroller of the Patent Office in attendance, received on Tuesday, March 12, 1918, a very large and important deputation—organised by the London Chamber of Commerce—at the Board of Trade, representative of the principal Chambers of Commerce of the country, the Federation of British Industries, the London and Eastern Associations of Controlled Firms, the Institution of Electrical Engineers, the Chemical Industries, the Newspaper Proprietors Associations, and others, introduced by Sir George Croydon Marks, M.P., for the purpose of making representations to the President concerning the new Bills to amend the Patents and Designs Act, 1917, and the Trade-Marks Act of 1905, which were introduced in the last Sessions of Parliament.

Sir George Croydon Marks, in introducing the deputation, explained that practically all the industries of the country were represented at the deputation; meetings of Scientific and other Societies and the Institutions and Federations connected with the different trades having already passed resolutions suggesting serious amendments to the Bills that had been introduced, as they were of opinion that the position of Patentees had not been fully appreciated by those who had drafted the Bills; while the proposals in reference to the Trade-Marks had created alarm, not only in this country, but in America, where it was felt that the sweeping reforms that were proposed would amount to almost the confiscation of the established rights and interests that had been built up in this country in accordance with the provisions and the safeguards of the existing legislation, under which it was believed that the heavy expenditure that had been incurred would be protected for the interests of those who had created the industries associated with the Trade-Marks in question.

The views of the different Societies and of the Chambers of Commerce were advanced by Mr. J. E. Evans-Jackson, Mr. W. M. Morday, Mr. C. Sampson, Mr. J. McDowell, Mr. A. E. Warden, and Mr. C. C. Ford, in the course of which the President was asked whether it would not be possible to introduce a short non contentious Bill that would permit a moratorium in reference to the lapsing of patents upon which fees are being paid during the war, but in connection with which no manufacture could be carried on due to the works being controlled and to the war claims of the nation.

It was pointed out concerning Trade-Marks that very serious contentions were advanced as to the grave injury which would result to the trading community of the country if Part II. of the Trade-Marks Bill was proceeded with.

Sir Albert Stanley, in replying to the deputation, stated that the Government hoped that it would be appreciated by all the industries that the measures introduced were in the nature of "war-time" measures, and were designed solely for the protection and the betterment of the industries, and without the slightest intention of hampering or restricting the trade or commerce of the country. On the other hand, abuses have crept up in the past that our enemies had been most assiduous to take advantage of; for example, they had endeavoured to build up by the use of Trade-Marks as the names of different products, perpetual monopolies that would prevent any person or any trader in this country from being able to supply those products, and thus while if a patent were granted there would be but a limited monopoly for fourteen years, when the process would become public property, yet by the astute coining of words to describe a product, that which was in effect created was a perpetual monopoly in connection with the product, which was undoubtedly to the detriment, alike of the public, and a serious menace to the development of manufactures of the industries of the country.

In reference to the suggestion that had been made for the introducing of a short Bill to extend the life of patents for the period of the war which had been stated to be non-contentious, his experience assured him that sometimes that which appeared a very non-contentious Bill provoked a great deal of opposition, and he was of opinion that there would be no greater difficulty in carrying through legislation to bring about all the desired reforms in connection with our Patent procedure than there would be to carry through a Bill dealing with only a portion, namely, the difficulties that had arisen in regard to the lapsing of patents that could not be worked during the present war.

All classes of the community suffered and had to make sacrifices alike of their interests and of their business during the war, and it would be impossible to place inventors and patentees, however important their inventions might be, in a privileged position; provision had been made in the Bill for extending the life of all patents, and also special provisions for extension were proposed when it could be shown that direct losses had resulted due to the war, while a corresponding benefit had been given to the nation in connection with the industries at the expense of the patentee.

The Bills were framed in a way that would admit of amendment, and he did not wish to indicate the character of the amendments that might be entertained, but he wished the deputation to clearly understand that the one object in view of his Department was to assist the industries and to develop the resources of the country by means of securing a betterment of the Patent laws, and the breaking down of the abuses of the monopolies that had hitherto been associated with Patents and Trade-Marks, so that it came almost as surprise to him to find that such criticisms had been advanced against the proposals, while apparently the real object of the Government had not been adequately appreciated by those who had examined the Bills.

As regards the Trade-Marks Bill, there were many words that had passed into common language and could be found in our dictionaries as the names of or descriptive of new products, words that were probably coined for the convenience of simple description and designation, and it would be unfair to the manufacturing and trading community of the country to permit a word which had become the only practical designation of devices or products that were now open to all in the Realm to produce, to be solely associated with the products and manufactures of one firm; for that would be creating monopolies of a perpetual character and hampering and restricting trades for the development of which the Patent law was solely and only created.

It must always be remembered that the granting of patents was for the encouragement and the development of industries by the creation of a limited monopoly for the benefit of those who introduced the new inventions; provisions, however, had always been made in the existing Statute to safeguard any abuse that might arise thereunder against the interests of the community as a whole.

Sir GEORGE CROYDON MARKS, in thanking Sir Albert Stanley, assured him that the deputation highly appreciated the sympathetic manner in which he had listened to their views and for the hint that had been given concerning the possibility of amendments that could be introduced to the existing Bills, such as might tend to remove or correct any misapprehension that may have arisen, alike in the minds of the trading community or in the wording or phraseology of the Bills, for carrying out the avowed intentions of the Government for the development of the industries of this country.

1, 2, and 3, Oxford Court, and
97, Cannon Street, London, E.C. 4.

CORRESPONDENCE.

TO LABORATORY APPARATUS DEALERS.

To the Editor of the Chemical News.

SIR,—I was looking at my list of apparatus and materials which the chemical dealer tells me must wait until the War is over before they can be obtained from Germany. I regret to say the list is a formidable one; I had to add to it this week. Few in our generation will ever knowingly purchase goods made in Germany if they can be obtained from other countries. We feel that German goods must appear to be smeared with the blood of our relatives and countrymen. I take it that my position is much the same as obtains with the heads of other laboratories in the country. Surely, therefore, it is time our British manufacturers realised that it is not much use tinkering with laboratory glass and porcelain ware, if the thousand and one other forms of laboratory apparatus have to be purchased in Germany after the War. It seems reasonable to suppose that the orders for laboratory glass and porcelain ware are bound to ultimately accompany the orders for the other requisites.—I am, &c.,

X. Y. Z.

SILICA BRICKS.

To the Editor of the Chemical News.

SIR,—I shall be obliged if any of your readers can recommend any book dealing with the manufacture and testing of high-class silica bricks. In fact, any information on this subject will be very welcome.—I am, &c.,

E. L. B.

MISCELLANEOUS.

Chemical Society.—The next Ordinary Scientific Meeting will be held on Thursday, April 18, 1918, at 8 p.m., when Sir Henry Miers, F.R.S., will deliver the Hugo Müller Lecture, entitled, "The Old and the New Mineralogy."

Queensland Dyes.—At the annual meeting of the Queensland Chamber of Manufacturers, Mr. J. Campbell, who was present by invitation, to give details of his experiments in North Queensland, said he felt very gratified, as an isolated worker in the North, to have the support and interest of such a body as the Chamber of Manufacturers. The four branches of products in which he was at present chiefly interested were paper pulp, fibre, dyes, and tanners' extracts. We had heard a good deal of the shortage of some of these articles, but it was an unnecessary shortage, for in the district in which he was working there were acres of materials which could be used for their manufacture. An excellent paper could be made from blady grass, China burr, sida retusa, and lantana. With his present machinery it was only possible to turn out two tons per week, but there was no reason why the output should not be increased to 400 tons per week, which was the requirement for the whole of Australia. It would mean a matter of £50,000 to erect a plant which would make us independent of outside supplies. In the matter of dyes he had been following to a large extent on the lines of his ancestors, the Highlanders, who, it was well known, extracted the dyes for their tartans from weeds. No fewer than fifty different shades had been taken by him from plants which could be had not only by the hundredweight but by the ton. He had only just taken up the study of colouring matter for confectioners. Recently he had received a mineral from a miner, and from that stone he had extracted a beautiful green and a blue dye. So far, he had got an excellent green, a fair red, a purple, and a yellow, and with the exception of the latter, these were all the products of vegetables. The yellow was obtained from the body of the wallaby, but he had found now that it could be also got from bark.—(London Correspondent of *The North Queensland Register*, Weavers' Hall, 22, Basinghall Street, London, E.C. 2).

Trade Organisation Development.—A Conference which is to take place between trade representatives and Government representatives in the Saddlers' Hall, London, on April 12, will mark a new point in the process of Trade Organisation, to which the country is now giving so much attention. On behalf of the Government three Ministries will be represented by their respective Ministers—Dr. Addison, Minister of Reconstruction; Mr. C. H. Roberts, Minister of Labour; and Mr. Hayes Fisher, President of the Board of Trade. The trade immediately concerned on this occasion is the Made-up Leather Goods and Belting Industry, and representatives both of employers and of employed will be present. The object of the meeting is to promote the formation, for this particular industry, of an "Interim Industrial Reconstruction Committee," and the movement is of interest to people of other trades because this Committee, it is hoped, will be the first of many similar Committees, to be formed by such trades and industries of the country as cannot see their way clear to forming at once a full Industrial Council for their trade on the lines recommended in the First Whitley Report. The Interim Industrial Reconstruction Committee is to serve as a stepping-stone or half way house to the full Industrial Council status. The First Whitley Report, it will be remembered, advocated a Joint Standing Industrial Council for each trade, but this recommendation was regarded as practicable only in such trades as had attained a considerable degree of industrial organisation as regards both employers and workers. Interim Industrial Reconstruction Committees are now advocated for such industries and trades as have not attained so complete a degree of organisation, and also for more highly organised trades in cases where there are difficulties in the way of forming Joint Standing Industrial Councils. They are intended to serve temporarily some of the functions allotted to Industrial Councils, but they have also one added function of great importance, namely, to promote organisation both of employers and of employed in their industry until each side has reached that degree of organisation which will admit of full Industrial Councils being formed. They are to give their attention also to other urgent problems which in the case of more fully organised industries will be dealt with by Industrial Councils. Among these problems are all the many trade

difficulties embraced under the general head "demobilisation" and the re-absorption into industry of men from the various branches of national service at home and abroad; also the problems that will arise from the shortage of raw materials and the general shortness of money. They will be asked to consider also such questions as new industries, the proper disposal of Government surplus stores, and other questions affecting the general welfare and prosperity of their industries. But the great function of Interim Industrial Reconstruction Committees will be to bring about, each within its own industry, that degree of organisation both on the part of the employers and on the part of the workers, and jointly on behalf of both, which will make possible the establishment for that trade of a full Industrial Council which can speak for its trade with one voice, act for it with the unanimous support of all its members, and represent it in the councils of the nation.

Iron and Steel Institute.—*Annual Meeting*, 1918.—The Annual Meeting of the Institute will be held, by kind permission, in the house of the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday, May 2 and 3, 1918, commencing on Thursday at 10.30 a.m., and on Friday at 10 a.m. The following is the programme of proceedings:—

Thursday, May 2 (at 10.30 a.m.).

General Meeting of Members.
The Council will present their Report for the year 1917.
The Hon. Treasurer will present the Statement of Accounts for 1917.
Scrutineers will be appointed for the examination of voting papers for election of new Members and Associates of the Institute.
The retiring President (Sir William Beardmore, Bart.) will induct into the Chair the President-Elect (Mr. Eugène Schneider).
Award of the Bessemer Medal for 1918 to Sir William Beardmore, Bart., Past President.
The President will deliver his Inaugural Address.
A selection of papers will be read and discussed.
The meeting will be adjourned.

Friday, May 3, (at 10 a.m.).

General Meeting of Members.
The award of grants from the Andrew Carnegie Research Fund in aid of research work will be announced.
A selection of papers will be read and discussed.
Those papers for which time cannot be found will be taken as read and discussed by correspondence.
Afternoon Sessions will also probably be held.

The list of papers expected to be submitted is given below, but it is possible that the publication of some of them may be restricted by the Censor.

Presidential Address by Mr. C. Eugène Schneider.
Report of the Blast Furnace Committee—"Practical Points affecting Yield and Efficiency of Blast Furnaces."
G. D. Cochrane—"Importance of Coke Hardness."
Dr. F. H. Hatch—"Economic Value of the Jurassic Iron Ores of Great Britain."
T. C. Hutchinson—"Fuel Economy in Blast Furnaces."
A. Lennox Leigh—"Economy in Gas Cleaning."
Kenneth Chance—"Potash Recovery from Blast Furnaces."
E. H. Lewis—"Manufacture of Portland Cement from Blast Furnace Slag."
Dr. J. E. Stead—"Blast Furnace Bears."
Dr. A. MacWilliam—"Technical Aspects of the Establishment of the Heavy Steel Industry in India, with Results of some Researches connected therewith."
B. Talbot—"Production of Sound Steel by Lateral Compression of the Top Portion of the Ingot."
J. N. Kilby—"Steel Ingot Defects."
Dr. J. E. Stead—"Notes on Inclusions in Steel and Ferrite Lines."
A. McCance—"Non-metallic Inclusions in Steel."
Dr. W. Rosenhain and D. Hanson—"A Cause of Brittleness in Mild Steel Boiler Plates."
E. F. Law—"Effect of Mass on Heat Treatment."
J. H. Whiteley—"Effect of Cold Work on the Divorce of Pearlite."
J. A. Van Den Broek—"Effect of Cold Working on the Elastic Properties of Steel."
Dr. J. E. Stead—"Iron, Carbon, and Phosphorus."
Col. N. Belaiew—"Damascene Steel."
Dr. J. N. Friend—"Protection of Iron with Paint against Atmospheric Corrosion."
W. R. Schoeller and A. R. Powell—"Determination of Cobalt and Nickel in Cobalt Steel."

To comply with Regulation 8 (b) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Junior Assistant Chemist required in the Laboratory of an Engineering Works in the South of England. Good knowledge of Theoretical Chemistry, with some experience in Analyses, desirable. No one need apply who has been passed for *Military service in a higher grade than Class B 2 or Grade III.* Give particulars of age, training, and salary required.—Address, E. W. Chemical News Office, 16, Newcastle Street, Farringdon Street London, E.C. 4.

Metallurgical Chemist wanted by Sheffield firm to take charge of shift on 7-ton Heroult furnace. Must have first-class experience with Carbon and Alloy Steels.—Address, S. F., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted for the Laboratory of large Chemical Factory, well-trained and experienced Analysts. Accurate and systematic workers required.—Address, C. B., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

PATENTS AND DESIGNS ACTS, 1907-1914.

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THE CHEMICAL NEWS

Vol. CXVII., No. 3046.

SPECIAL NOTICE TO SUBSCRIBERS.

We regret to announce that the recent paper restrictions will compel us for a period, until we can secure our usual supply of paper, to publish the Chemical News fortnightly instead of weekly.

The price will not be altered, except as regards the subscription price, which, until further notice, will be calculated at £1 for fifty-two numbers, or *pro rata*.

Subscribers will please note that the respective expiration dates of their subscriptions will be extended accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their extended subscription periods.

The next issue (No. 3047) will be published on May 10th.

THE COMPLEXITY OF THE CHEMICAL ELEMENTS.*

By Prof. FREDERICK SODDY, M.A., F.R.S.

(Concluded from p. 160).

Thorium and Ionium.

A second quite independent case of a difference in atomic weight between isotopes has been established. It concerns the isotopes thorium and ionium, and it is connected in an important way with the researches which, on two previous occasions, I have given an account of here, the researches on the growth of radium from uranium, which have been in progress now for fourteen years. It is the intervention of ionium and its very long period of life which has made the experimental proof of the production of radium from uranium such a long piece of work. Previously only negative results were available. One could only say, from the smallness of the expected growth of radium, that the period of average life of ionium must be at least 100,000 years, forty times longer than that of radium, and, therefore, that there must be at least forty times as much ionium by weight as radium in uranium minerals, or at least 13·6 grms. per 1000 kilos. of uranium. Since then further measurements, carried out by Miss Hitchins last year, have shown definitely for the first time a clear growth of radium from uranium in the largest preparation, containing 3 kilos. of uranium, and this growth, as theory requires, is proceeding according to the square of the time. In three years it amounted to 2×10^{-11} grms. of radium, and in six years to just four times this quantity. From this result it was concluded that the previous estimate of 100,000 years for the period of ionium, though still of the nature of a minimum rather than a maximum, was very near to the actual period.

Joachimsthal pitchblende, the Austrian source of radium, contains only an infinitesimal proportion of thorium. An ionium preparation separated, by Auer von Welsbach, from 30 tons of this mineral, since no thorium was added during the process, was an extremely concentrated ionium preparation. The atomic weight of ionium—calculated by adding to the atomic weight of its product, radium, four for the a-particle expelled in the change—is 230, whereas that of thorium, its isotope, is slightly above 232. The question was whether the ionium-thorium preparation would contain enough ionium to show the difference. Hönigschmid and Mlle. Horovitz have made a special examination of the point, first redetermining as accurately as possible the atomic weight of thorium and then that of the thorium-ionium preparation from pitchblende. They found 232·12 for the atomic weight of thorium, and by the same method 231·51 for that of the ionium-thorium. A very careful and complete examination of the spectra of the two materials showed for both absolutely the same spectrum and a complete absence of impurities.

If the atomic weight of ionium is 230, the ionium-thorium preparation must, from its atomic weight, contain 30 per cent of ionium and 70 per cent of thorium by weight. Prof. Meyer has made a comparison of the number of a-particles given per second by this preparation with that given by pure radium, and found it to be in the ratio of 1 to 200. If 30 per cent is ionium, the activity of pure ionium would be one-sixtieth of that of pure radium, its period some sixty times greater, or 150,000 years. This confirms in a very satisfactory manner our direct estimate of 100,000 years as a minimum, and incidentally raises rather an interesting question.

My direct estimate involves directly the period of uranium itself, and if the value accepted for this is too high, that for the ionium will be correspondingly too low. Now, last week, Prof. Joly was bringing before you, I believe, some of his exceedingly interesting work on pleochroic halos, from which he has grounds for the conclusion that the accepted period of uranium may be too long. But since I obtained, for the period of ionium, a minimum value two-thirds of that estimated by Meyer from the atomic weight, it is difficult to believe that the accepted period of uranium can have been over-estimated by more than 50 per cent of the real period. The matter could be pushed to a further conclusion if it were found possible to estimate the percentage of thorium in the thorium-ionium preparation, a piece of work that ought not to be beyond the resources of radio-chemical analysis. This would then constitute a check on the period of uranium as well as on that of ionium. Such a direct check would be of considerable importance in the determination of geological ages.

The period of ionium enables us to calculate the ratio between the weights of ionium and uranium in pitchblende, as 17·4 to 10⁹, and the doctrine of the non-separability of isotopes leads directly to the ratio between the thorium and uranium in the mineral, as 41·7 to 10⁹. This quantity of thorium is, unfortunately, too small for direct estimation. Otherwise it would be possible to devise a very strict test of the degree of non-separability. As it is, the work is sufficiently convincing. Thirty tons of a mineral containing a majority of the known elements in detectable amount, in the hands of one whose researches in the most difficult field of chemical separation are world-renowned, yield a preparation of the order of one-millionth of the weight of the mineral, which cannot be distinguished from pure thorium in its chemical character. Anyone could tell in the dark that it was not pure thorium, for its a-activity is 30,000 times greater than that of thorium. This is then submitted to that particular series of purifications designed to give the purest possible thorium for an atomic weight determination, and it emerges without any separation of the ionium, but with a spectrum identical with that of a control specimen of thorium similarly purified. The complete absence of impurities in the spectrum show that the chemical work has been very effectively done, and the atomic weight shows that it must contain 30 per cent by weight of the isotope

* A paper read before the Royal Institution, May 18, 1917.

ionium, a result which agrees with its α-activity and the now known period of the latter.

Determination of Atomic Weights.

The results enumerated thus prove that the atomic weight can no longer be regarded as a natural constant, or the chemically pure element as a homogeneous type of matter. The latter may be, and doubtless often is, a mixture of isotopes varying in atomic weight over a small number of units, and the former then has no exact physical significance, being a mean value in which the proportions of the mixture as well as the separate atomic weights are both unknown. New ideals emerge and old ones are resuscitated by this development. There may be after all a very simple numerical relation between the true atomic weights. The view that seems most probably true at present is that while hydrogen and helium may be the ultimate constituents of matter in the Proutian sense, and the atomic weights therefore approximate multiples of that of hydrogen, small deviations, such as exist between the atomic weights of these two constituent elements themselves, may be due to the manner in which the atom is constituted, in accordance with the principle of mutual electro-magnetic mass, developed by Silberstein and others. The electro-magnetic mass of two charges in juxtaposition would not be the exact sum of the masses when the charges are separated. The atomic weight of hydrogen is 1·0078 in terms of that of helium as 3·99, and that the latter is not exactly four times the former may be the expression of this effect. Harkins and Wilson have recently gone into the question with some thoroughness, and the conclusion of most interest in the present connection, which appears to emerge, is in favour of regarding most of the effect to occur in the formation of helium from hydrogen, and very little in subsequent aggregations of the helium. In the region of the radio-elements, where we have abundant examples of the expulsion of helium atoms as α-particles, it seems as if we could almost safely neglect this effect altogether. Thus radium has the atomic weight almost exactly 226, and the ultimate product almost exactly 206, showing that in 5 α- and 4 β-ray changes the mean effect is nil, and the atomic weights are moreover integers in terms of oxygen as 16, or helium 4. It is true that the atomic weights of both thorium and uranium are between 0·1 and 0·2 greater than exact integers, but it is difficult to be sure that this difference is real.

When, among the light elements, we come across a clear case of large departure from the integral value, such as magnesium 24·32 and chlorine 35·46, we may reasonably suspect the elements to be a mixture of isotopes. If this is true for chlorine, it suggests a most undesirable feature in the modern practice of determining atomic weights. More and more the one method has come to be relied upon. The preparation of the chloride of the element and the comparison of its weight with that of the silver necessary to combine with the chlorine, and with the weight of the silver chloride formed.

Almost the only practical method, and that a very laborious and imperfect one, which may be expected to resolve a mixture of isotopes, is by long-continued fractional gaseous diffusion, which is likely to be the more effective the lower the atomic weight. Assume, for example, chlorine were a mixture of isotopes of separate atomic weights 34 and 36, or 35 and 36. The 34 isotope would diffuse some 3 per cent faster than the 36, and the 35 some 1·5 per cent faster.

The determination of the atomic weight of chlorine in terms of that of silver has reached now such a pitch of refinement that it should be able to detect a difference in the end fractions of the atomic weight of chlorine, if chlorine or hydrogen chloride were systematically subjected to diffusion. It is extremely desirable that such a test of the homogeneity of this gas should be made in this way.

Clearly a change must come in this class of work. It is not of much use starting with stuff out of a bottle labelled "purissimum" or "garantirt," and in determining to the highest possible degree of accuracy the atomic weight of an element of unknown origin. The great pioneers in the subject, like Berzelius, were masters of the whole domain of inorganic chemistry, and knew the sources of the elements in Nature first-hand. Their successors must revert to their practice and go direct to Nature for their materials, must select them carefully with due regard to what geology teaches as to their age and history, and, before carrying out a single determination, they must analyse their actual raw materials completely, and know exactly what it is they are dealing with. Much of the work on the atomic weight of lead from mixed minerals is useless for failure to do this. They must rely more on the agreement, or disagreement, of a great variety of results by methods as different and for materials as different as possible, rather than on the result of a single method pushed to the limit of refinement, for an element provisionally purified by a dealer from quite unknown materials. The preconceived notion that the results must necessarily agree if the work is well done must be replaced by a system of co-operation between the workers of the world checking each other's results for the same material. A year ago anyone bold enough to publish atomic weight determinations which were not up to the modern standards of agreement among themselves would have been regarded as having mistaken his vocation. If these wider ideals are pursued all the labour that has been lavished in this field, and which now seems to have been so largely wasted, may possibly bear fruit, and where the newer methods fail, far below the narrow belt of elements which it is possible to watch changing, the atomic weight worker may be able to pick up the threads of the great story. No doubt it is writ in full in the natural records preserved by rock and mineral, and the evidence of the atomic weights may be able to carry to a triumphant conclusion the course of elementary evolution, of which as yet only an isolated chapter has been deciphered.

The Structure of the Atom.

The third line of recent advance, which does much to explain the meaning of the isotopes and the Periodic Law, starts from Sir Ernest Rutherford's nuclear theory of the atom, which is an attempt to determine the nature of atomic structure, which again is the necessary preliminary to the understanding of the third aspect in which the elements are or may be complex. That uranium and thorium are built up of different isotopes of lead, helium, and electrons is now an experimental fact, since they have been proved to change into these constituents. But the questions how they are built up, and what is the nature of the non-radioactive elements, which do not undergo changes, remain unsolved.

Prof. Bragg showed in 1905 that the α-particles can traverse the atoms of matter in their path almost as though they were not there. As far as he could tell, and the statement is still true of the vast majority of α-particles colliding with the atoms of matter, the α-particle ploughs its way straight through, pursuing a practically rectilinear course, losing slightly in kinetic energy at each encounter with an atom, until its velocity is reduced to the point at which it can no longer be detected. From that time the α-particle became as it were a messenger that could penetrate the atom, traverse regions which hitherto had been bolted and barred from human curiosity, and on re-emerging could be questioned, as it was questioned effectively by Rutherford, with regard to what was inside. Sir J. J. Thomson, using the electron as the messenger, had obtained valuable information as to the number of electrons in the atom, but the massive material α-particle alone can disclose the material atom. It was found that, though the vast majority of α-particles re-emerge, from their encounters with the atoms, practically in the same direction as they started, suffering only slight hither and thither scattering due to their collisions with the electrons in the atom, a minute proportion of them suffer very large and abrupt changes of direction. Some are swung round,

emerging in the opposite to their original direction. The vast majority that get through all but undeflected have met nothing in their passage save electrons, 8000 times lighter than themselves. The few that are violently swung out of their course must have been in collision with an exceedingly massive nucleus in the atom, occupying only an insignificant fraction of its total volume. The atomic volume is the total volume swept out by systems of electrons in orbits of revolution round the nucleus, and beyond these rings or shells guarding the nucleus it is ordinarily impossible to penetrate. The nucleus is regarded by Rutherford as carrying a single concentrated positive charge, equal and opposite to that of the sum of the electrons.

Chemical phenomena deal almost certainly with the outermost system of the detachable or valency electrons alone, the loss or gain of which conditions chemical combining power. Light spectra originate probably in the same region, though possibly more systems of electrons than the outermost may contribute, while the X-rays and γ-rays seem to take their rise in a deep-seated ring or shell around the nucleus. But mass phenomena, all but an insignificant fraction, originate in the nucleus.

In the original electrical theory of matter the whole mass of the atom was attributed to electrons, of which there would have been required nearly 2000 times the atomic weight in terms of hydrogen as unity. With the more definite determination of this number, and the realisation that there were only about half as many as the number representing the atomic weight, it was clear that all but an insignificant fraction of the mass of the atom was accounted for. In the nuclear hypothesis this mass is concentrated in the exceedingly minute nucleus. The electromagnetic theory of inertia accounts for the greater mass if the positive charges that make up the nucleus are very much more concentrated than the negative charges which constitute the separate electrons. The experiments on scattering clearly indicated the existence of such a concentrated central positive charge or nucleus.

The mathematical consideration of the results of α-ray scattering, obtained for a large number of different elements, and for different velocities of α-ray, gave further evidence that the number of electrons, and therefore the + charge on the nucleus, is about half the number representing the atomic weight. But van der Broek, reviving an isolated suggestion from a former paper full of suggestions on the Periodic Law, which were, I think, in every other respect at fault, suggested that closer agreement with the theory would be obtained if the number of electrons in the atom, or the nuclear charge, was the number of the place the element occupied in the Periodic Table. This is now called the atomic number, that of hydrogen being taken as 1, helium 2, lithium 3, and so on to the end of the table, uranium 92, as we now know. For the light elements it is practically half the atomic weight; for the heavy elements rather less than half.

I pointed out this accorded well with the law of radioactive change that had been established to hold over the last thirteen places in the Periodic Table. This law might be expressed as follows:—The expulsion of the α-particle carrying two positive charges lowers the atomic number by two, while the expulsion of the β-particle, carrying a single negative charge, increases it by one. In ignorance of van der Broek's original suggestion, I had, in representing the generalisation, shown the last thirteen places as differing by unit by unit in the number of electrons in the atom.

Then followed Moseley's all-embracing advance, showing how from the wave-lengths of the X-rays, characteristic of the elements, this conception explained the whole Periodic Table. The square roots of the frequency of the characteristic X-rays are proportional to the atomic numbers. The total number of elements existing between uranium and hydrogen could thus be determined, and it was found to be 92, only five of the places being vacant. The "exceptions" to the Periodic Law, such as argon and potassium, nickel and cobalt, tellurium and iodine, in which an element with higher atomic weight precedes instead of succeeds one with lower, was confirmed by the determination of the atomic numbers in every case. From now on, this number, which represents the + charge on the nucleus, rather than the atomic weight, becomes the natural constant which determines chemical character, light and X-ray spectra, and, in fact, all the properties of matter, except those that depend directly on the nucleus—mass and weight on the one hand, and radioactive properties on the other.

What, then, were the isotopes on this scheme? Obviously they were elements with the same atomic number, the same *nett* charge on the nucleus, but with a differently constituted nucleus. Take the very ordinary sequence in the disintegration series, one α- and two β-rays being successively expelled in any order. Two + and two − charges have been expelled, the *nett* charge of the nucleus remains the same, the chemical character and spectrum the same as that of the first parent, but the mass is reduced 4 units because a helium atom, or rather nucleus, has been expelled as an α-particle. The mass depends on the *gross* number of + charges in the nucleus, chemical properties on the difference between the gross numbers of + and − charges. But the radioactive properties depend not only on the gross number of charges but on the constitution of the nucleus. We can have isotopes with identity of atomic weight, as well as of chemical character, which are different in their stability and mode of breaking up. Hence we can infer that this finer degree of isotopy may also exist among the stable elements, in which case it would be completely beyond our present means to detect. But when transmutation becomes possible such a difference would be at once revealed.

The case is not one entirely of academic interest, because it is probable that the reconciliation of the conflicting views of the geologists and chemists, who concluded that lead was not the ultimate product of thorium, and those who by atomic weight demonstrations on the lead have shown that it is, depends probably on this point.

As has long been known, thorium-C, an isotope of bismuth, disintegrates dually. For 35 per cent of the atoms disintegrating, an α-ray is expelled followed by a β ray. For the remaining 65 per cent the β-ray is first expelled and is followed by the α-ray. The two products are both isotopes of lead, and both have the same atomic weight, but they are not the same. More energy is expelled in the changes of the 65 per cent fraction than in those of the 35 per cent. Unless they are both completely stable a difference of period of change is to be anticipated.

The same thing is true for radium-C, but here all but a very minute proportion of the atoms disintegrating follow the mode followed by the 65 per cent in the case of thorium-C. The product in this case, radium-D, which, of course, is also an isotope of lead, with atomic weight 210, is *not* permanently stable, though it has a fairly long period, twenty-four years. The other product is not known to change further, but then, even if it did, it is in such small quantity that it is doubtful whether the change would have been detected. But, so far as is known, it forms a stable isotope of lead of atomic weight 210, formed in the proportion of only 0·03 per cent of the whole.

Now the atomic weight evidence merely shows that *one* of the two isotopes of lead formed from thorium is stable enough to accumulate over geological epochs, and it does not necessarily follow that both are. Dr. Arthur Holmes has pointed out to me that the analysis I gave of the Ceylon thorite leads to a curiously anomalous value for the age of the mineral. The quantity of thorium lead per grm. of thorium is 0·0062, and this, divided by the rate at which the lead is being produced, $4·72 \times 10^{-11}$ grm. of lead per grm. of thorium per year, gives the age as 131 million years. But a Ceylon pitchblende, with uranium

72·88 per cent and lead 4·65 per cent, and ratio of lead to uranium as 0·064, gives the age as 512 million years. Dr. Holmes regards the two minerals as likely to be of the same age, and the pitchblende to be, of all the Ceylon results, the one most trustworthy for age measurement.

If we suppose that, as in the case of radium D, the 65 per cent isotope of lead derived from thorium is *not stable*, and that only the 35 per cent isotope accumulates, the age of the mineral would be 375 million years, which the geologists are likely to consider much more nearly the truth. But the most interesting point is that, if we take the atomic weight of the lead isotope derived from uranium as 206·0, and that derived from thorium as 208·0, and calculate the atomic weight of the lead in Ceylon thorite, assuming it to consist entirely of uranium lead and of only the 35 per cent isotope from thorium, we get the value 207·74, which is exactly what I found from the density, and what Prof. Hönigschmid determined (207·77).

The question remains, if this is what occurs, what does this unstable lead change into? If an α-particle were expelled mercury would result, or if a β-particle bismuth, two elements of which I could find no trace in the lead group separated from the whole 20 kilos. of mineral. But if an α- and a β-particle were both expelled, the product would be thallium, which is present in amount small but sufficient for chemical as well as spectroscopic characterisation. If the process of disintegration does proceed as suggested, it should be possible to trace it, for this particular lead should give a feeble specific α- or β-radiation, in addition, of con se, to that due to other lead isotopes. So far it has not been possible to test this. In the meantime, the explanation offered is put forward provisionally as being consistent with all the known evidence.

Looking for a moment in conclusion at the broader aspects of the new ideas of atomic structure, it seems that though a sound basis for further development has been roughed out, almost all the detail remains to be supplied. We have got to know the nucleus, but beyond the fact that it is constituted, in heavy atoms, of nuclei of helium and electrons, nothing is known. Whilst as regards the separate shells or rings of electrons which neutralise its charge and are supposed to surround it, like the shells of an onion, we really know nothing yet at all. The original explanation, in terms of the electron, of the periodicity of properties displayed by the elements, still remains all that has been attempted. We may suppose, as we pass through the successive elements in the table, one more electron is added to the outermost ring for each unit increase in the charge on the nucleus, or atomic number, and that when a certain number, 8 in the early part of the table, 18 later, a complete new stable shell or ring forms, which no longer participates directly in the chemical activities of the atom. Thanks, however, to Moseley's work, this now is not sufficiently precise; for we know the exact number of the elements, and the various atomic numbers at which the remarkable changes, in the nature of the periodicity displayed, occur. Any real knowledge in this field will account not only for the two short initial periods, but also for the curious double periodicity later on, in which the abrupt changes of properties in the neighbourhood of the zero family alternate with the gradual changes in the neighbourhood of the VIIIth groups. The extraordinary exception to the principle of the whole scheme presented by the rare-earth elements remain a complete enigma, none the less impressive because, beyond them again in the table, the normal course is resumed and continues to the end.

Violet Rays and Ferrous Ammonium Sulphate.—The decinormal solution stocked in actinic blue bottles is apt to rapidly deteriorate on use if kept in ordinary glass. In this way the factor for correcting such solutions can change in eighteen hours, *e.g.*, from 1·00 to 0·90, a measure of actinic effect.—J. C. Thomlinson, B.Sc.

THE

DETERMINATION OF MOISTURE IN COKE.

By ARNO C. FIELDNER and WALTER A. SELVIG.

Introduction.

The experiments described in this paper were undertaken, in the course of fuel investigations made by the Bureau of Mines, with the purpose of ascertaining the most rapid and simple method for determining the moisture in coke with sufficient accuracy for use in specifications for the purchase of coke by the Government, by industrial concerns, or by private individuals.

For the determination of moisture in coal, the Committee on Coal Analysis of the American Society for Testing Materials and the American Chemical Society ("Tentative Methods for Laboratory Sampling and Analysis of Coal," "Year Book, Am. Soc. Test. Mat.," 1915, p. 600) recommend heating the pulverised sample (60-mesh) for one hour at 104—110° C. in an oven through which is passed a rapid current of air dried by passing through concentrated sulphuric acid. Under the same conditions 20-mesh samples must be heated one and a-half hours.

In order to obtain comparable results, the method specified must be strictly followed, especially with coals normally having a high moisture content. Experiments have shown that such coals will easily give off 1 per cent more moisture in an atmosphere having a high moisture content. Experiments have shown that such coals will easily give off 1 per cent more moisture in an atmosphere of circulating dry air than in an atmosphere of more or less stagnant air in which there is an appreciable partial pressure of water-vapour. It is also essential, in order to obtain the correct moisture content, to pulverise the coal to a fineness of at least 10-mesh before the final moisture determination. The best practice is to air-dry the coal at ½ or ¼ inch size, and then to pulverise it for the final determination of residual moisture, thus determining the water in two stages.

Undoubtedly the above method for the determination of moisture in coal gives results of the same degree of accuracy when applied to coke. However, owing to the much greater stability of coke as compared to coal, it is believed that a simpler method gives accurate results.

Coal is a complex mixture of extremely sensitive organic compounds containing a considerable proportion of hydrogen and oxygen. These compounds are easily altered by heating and by oxidation. On the other hand coke is the residual product obtained from heating coal to a high temperature, and consists chiefly of carbon and inorganic ash-forming constituents. The hydrogen and oxygen content is less than 1 per cent, and the carbon is fused, so that the great number of very finely-divided particles of the original coal substance, which afforded a vast surface system for the condensation of moisture films are united.

It therefore seems probable that the circulation of dried air is unnecessary; that larger temperature limits than 104—110° C. are permissible; that no appreciable gain in weight due to absorption of oxygen takes place on heating longer than one hour, and, finally, that practically all the moisture should be removed on heating the unpulverised coke to constant weight. If the latter procedure is permissible the ever present danger of loss of moisture during pulverisation will be eliminated, and will be possible to determine the moisture content of shipment of coke with the same ease and simplicity as f iron ores.

Review of the Literature.

Comparatively few reports of experiments on the determination of moisture in coke have been published. Mo text-books recommend the same procedure as for coal. few investigators have recognised that coke may be dri to constant weight in much the same manner as ore dried.

TABLE I.—*Results of Determining Moisture at* 105° C. *in* 60 *mesh Coke, with and without Dry-air Circulation.*

Coke No.	Percentage of moisture. Heated 1 hour in current of dry air. Set 1.	Set 2.	Average.	Heated 1 hour in stagnant air. Set 3	Set 4.	Average.	Heated 2 hours in stagnant air.	Difference. Columns 4 and 7.	Columns 7 and 8.
1	2.	3.	4.	5.	6.	7.	8.	9.	10.
13651	0·15	0·16	0·16	0·15	0·16	0·16	0·19	0·00	+0·03
13672	0·26	0·27	0·27	0·26	0·30	0·28	0·33	+0·01	+0·05
13707	0·20	0·17	0·19	0·16	0·21	0·19	0·21	0·00	+0·02
13743	0·63	0·68	0·66	0·60	0·67	0·64	0·71	−0·02	+0·07
13784	0·07	0·10	0·09	0·07	0·11	0·09	0·06	0·00	−0·03
13879	0·12	0·13	0·13	0·12	0·10	0·11	0·09	−0·02	−0·02
13388	0·11	0·10	0·11	0·10	0·10	0·10	0·10	−0·01	0·00
14172	0·09	0·13	0·12	0·12	0·12	0·12	0·08	0·00	−0·04
14183	0·33	0·33	0·33	0·32	0·33	0·33	0·30	0·00	−0·03
14730	0·44	0·48	0·46	0·47	0·53	0·50	0·47	+0·04	−0·03
15276	0·21	0·22	0·22	0·21	0·21	0·22	0·22	0·00	0·00
16933	0·37	0·36	0·37	0·30	0·31	0·31	0·37	−0·06	+0·06
						Average..	.. .. ..	−0·005	+0·007

Thörner recommends that the gross sample of coke be ılverised and quartered to hazel nut size immediately er collection ("Beitrage zur bestimmung der Feuchtigkeit ıd Asche in Koks," *Stahl und Eisen*, Bd. viii., Th. 2, 1888 , 589). A representative portion of 1200 to 1500 grms. placed in a galvanised-iron can, sealed moisture-tight, ıd shipped to the laboratory. At the laboratory a glass be is inserted in a suitable opening in the can, and pushed *ıwn until the end is near the bottom.* The *can is then* ighed, placed in an air-oven at 105—110° C., and heated constant weight while a current of air is drawn through e tube. Usually eight to ten hours are required to move all the moisture.

The 1912 report of the Committee on standard methods r determining the constituents of foundry coke specifies at the gross sample of coke shall be crushed to ½ inch size, ixed, and quartered ("Report of the Committee on Standard ethods for Determining the Constituents of Foundry ›ke," *Trans. Am. Foundrymen's Assoc.*, 1912, xxi., 143). ıe quarter shall be reserved for the determination of total oisture. This determination consists in drying to conant weight at 104—107° C.

Wagener found that saturated lump coke containing 16 20 per cent water lost 4 per cent water while being ılverised, and put through a sieve having 4 mm. meshes Ueber den Wasser- und-Aschengehalt des Kokses," *rrum*, 1913, Bd. x., 321, 353). Unsaturated coke conining 9 per cent water *lost from* 1 *to* 2 *per* cent water. o avoid this loss of moisture Wagener recommended that e gross sample of coke be quickly broken down to fist ze with a hammer, then mixed and quartered. Two posite quarters weighing about 60 kgrms. are weighed a tared galvanised-iron pan, placed in a large oven, ıd dried for twenty-four hours at a temperature of 150° The loss in weight is the total moisture. This dried mple is then pulverised and analysed, it being assumed at moisture is reabsorbed from the atmosphere during e pulverising process.

Effect of Dry-air Circulation and Duration of Heating.

The first series of tests by the authors of this paper re made to ascertain whether the circulation of dry air rough the oven is necessary to remove the maximum nount of moisture. Twelve samples of different metalrgical cokes from various sources were prepared by ushing the air-dry coke to 60 mesh. Moisture deterinations were made in duplicate by the standard method ed by the Bureau of Mines for determining moisture in al (F. M. Stanton and A. C. Fieldner, "Methods of ıalysing Coal and Coke, *Tech. Paper* 8, Bureau of ines, 1913, p. 12). Samples weighing 1 grm. were aced in ⅞-inch by 1⅜-inch porcelain capsules, and in sets 12 heated for one hour at 105° C. in a constant temperare oven. A current of air, dried by concentrated sulphuric acid, was passed through the oven and over the samples rapidly enough to change the total volume of air in the oven two to four times in one minute. At the end of the heating period the capsules were covered with closely fitting flat aluminium covers, and cooled in separate desiccators over concentrated sulphuric acid. Each capsule was rapidly weighed to the nearest 0·5 mgrm. immediately upon removal from the desiccator.

Duplicate *determinations were also made in sets of* 12 in the same oven without using dry-air circulation, and a fifth set of determinations was made in which the period of heating was extended to two hours, in order to ascertain whether any gain in weight through absorption of oxygen took place. Coal samples heated for two hours usually show less loss in weight than samples heated for one hour.

As shown in Table I. no appreciable difference in moisture was obtained by circulating dry air through the oven. The difference for the 12 samples was only 0·005 per cent. Neither was there any appreciable change in weight on heating the samples for two hours.

Effect of Temperature.

The second series of tests were made to ascertain the effect of heating the 60 mesh coke at temperatures higher than 105° C. Three sets of determinations were made, namely, set No. 1 by the standard method at 105° C. as in the first series; set No. 2 by heating in stagnant air at 150° C.; and set No. 3 by heating in stagnant air at 200° C. Each set was heated for a period of one hour, then cooled over concentrated sulphuric acid, and weighed; then it was returned to the oven, heated for an additional thirty minutes, and again weighed. The results are given in Table II.

For each of the three temperatures, 105°, 150°, and 200° C., the loss in weight for one hour was practically the same as that attained through additional heating for thirty minutes. There was, however, a slightly greater loss at the higher temperatures. The greatest difference between 105° and 150° C. was 0·20 per cent, and between 105° and 200° C. was 0·31 per cent. The average differences were 0·11 and 0·20 per cent respectively.

It is probable that the greater loss at the higher temperatures is due to the removal of residual traces of water and gases condensed in extremely thin films on the surfaces of the coke particles. Mack and Hulett ("The Water Content of Coal, with some Ideas on the Genesis and Nature of Coal," *Am. Journ. Sci.*, Ser. 4, 1917, xliii., 89) have called attention to these films in connection with the water in coal, and have pointed out that such water would probably have no measurable vapour-pressure at 100° C., but would gradually, as the temperature increased, develop sufficient vapour-pressure to permit removal of additional moisture at higher temperature. However, the differences that were obtained on heating

the coke powder between limits of 105° and 150° C. may be regarded as negligible; even the maximum difference of 0·31 per cent at 200° C. is within the unavoidable moisture variations likely to be incurred in preparing the gross sample for analysis.

Table II.—*Results of Determination of Moisture in 60-mesh Coke at various Temperatures.*

Coke No.	Percentage of moisture. Heated in current of dry air at 105° C.		Heated in stagnant air at 150° C.		Heated in stagnant air at 200° C.		Difference. Cols. 3 and 5.	Cols. 3 and 7.
	1 hr.	1½ hrs.	1 hr.	1½ hrs.	1 hr.	1½ hrs.		
1.	2.	3.	4.	5.	6	7.	8.	9.
13651	0·15	0·15	0·30	0·31	0·36	0·37	0·16	0·22
13672	0·21	0·22	0·42	0·42	0·51	0·53	0·20	0·31
13707	0·20	0·22	0·28	0·29	0·32	0·34	0·07	0·12
14172	0·12	0·13	0·23	0·23	0·30	0·30	0·10	0·17
13743	0·66	0·70	0·84	0·89	0·95	0·96	0·19	0·26
13784	0·08	0·09	0·11	0·11	0·16	0·18	0·02	0·09
14183	0·31	0·31	0·49	0·47	0·62	0·62	0·16	0·31
16933	0·36	0·39	0·51	0·51	0·59	0·59	0·12	0·20
14730	0·54	0·55	0·65	0·65	0·79	0·80	0·10	0·25
15276	0·26	0·26	0·35	0·36	0·45	0·47	0·10	0·21
13888	0·11	0·11	0·15	0·15	0·23	0·25	0·04	0·14
13829	0·13	0·13	0·22	0·22	0·28	0·28	0·09	0·15
				Average	..	..	0·11	0·20

Direct Determination of Moisture in Lump Coke.

Experiments on the direct determination of moisture in 1 inch lumps and also in 4-mesh coke at various temperatures were made in the following manner:—

A large sample of coke was taken from a pile that was wet from a recent rain, and was crushed to 4-mesh size. This sample was then thoroughly mixed and divided into three representative portions, A1, A2, and A3, which were treated as described below.

Sample A1 was air-dried to constant weight at 30—35° C., then rapidly crushed to 10-mesh by passing it through crushing rolls. The 10-mesh product was quickly reduced on a riffle sampler to 400 grms., which was pulverised to 60-mesh in an air-tight porcelain Abbe ball mill containing flint pebbles. The 60-mesh sample was then reduced to 60 grms. on a small riffle sampler, and placed in a rubber-stoppered bottle. The residual moisture in this air-dried sample was determined at 105° C., according to the standard method previously described in this paper. The total moisture "as received" in sample A1 was computed as follows:—

$$\text{Moisture "as received"} = \text{moisture in 60-mesh coke} \times \frac{(100 - \text{air-drying loss})}{100} + \text{air-drying loss.}$$

In order to check any possible change of moisture content in the air-dry sample, while it was being pulverised and reduced from 4-mesh to 60-mesh, samples for moisture determinations were taken at various stages of the sampling procedure as follows:—

Table III.—*Percentage of Moisture in Air-dry Coke at various Stages in the Preparation of the 60-mesh Laboratory Sample.*

Kind of sample.	Moisture. Per cent.
4-mesh sample taken immediately after air-drying, 341·5 grms. dried to constant weight at 150° C.	0·32
10-mesh sample taken immediately after passing through rolls, 433·6 grms. dried to constant weight at 150° C.	0·23
60 mesh sample taken immediately after opening ball mill, 1 grm. dried one hour at 105° C. in a current of dry air	0·34
Final 60 grms. laboratory sample, determination as above	0·35

The maximum variation in the different samples was 0·12 per cent, which is of the same magnitude as the error in the moisture determination. Hence it may be assumed that the "as received" moisture as determined in sample A1 is the true moisture content of the coke, and may be used as a standard of reference for judging the accuracy of the results that were obtained on samples B and C by shorter methods.

Sample A2 (at 4-mesh size) was dried to constant weight at a temperature of 105° C. in a Freas electrically heated oven without dry-air circulation, and sample A3 (at 4-mesh size) was similarly dried to constant weight in an ordinary gas heated oven at a temperature of 150° C. The results obtained on the three samples are given in Table IV., together with the results on a second set of three samples, B1, B2, and B3, which were similarly prepared from another lot of coke.

Table IV.—*Results obtained by Heating 4-mesh Coke to various Temperatures.*

Sample	Fineness.	Temperature of drying.	Time required to reach constant weight.	Loss in weight.
		°C.	Hours.	P.c.
Sample A1, 2056 grms.	4-mesh	30—35	120	10·1
Sample A1, 1 grm. ..	60-mesh	105	1	0·35
Total moisture "as received"				10·4
Sample A2, 1089 grms.	4-mesh	95—105	2·5	10·5
Sample A3, 514 grms.	4-mesh	150	2·0	10·5
Sample B1, 1630 grms.	4-mesh	30—35	72	9·7
Sample B1, 1 grm. ..	60-mesh	105	1	0·38
Total moisture "as received"				10·0
Sample B2, 750·2 grms.	4-mesh	95—105	2·5	9·7
Sample B3, 426·2 grms.	4-mesh	150	2·0	9·7

Table IV. shows that moisture can be determined in 4-mesh coke by drying to constant weight at temperatures between 105° and 150° C., with practically the same degree of accuracy as in the longer process of first air-drying at 4-mesh size, and then pulverising the coke to 60-mesh for final drying at 105° C. in circulating dry air.

Determination of Moisture by Drying Lump Samples on Hot Plate.

The next step in the simplification of the method of determining moisture in coke was to ascertain whether it would be permissible to dry comparatively large samples (10 pounds or more) of 1 or 2 inch lumps to constant weight on an ordinary hot plate, coil of steam pipes, or similar device such as would be readily available at the point of sampling a shipment of coke. If such a procedure were possible the total moisture could be determined on the spot. The sample for chemical analysis could then be pulverised to 4-mesh size and quartered down to a 5-pound sample for shipment to the laboratory without special precautions for avoiding the almost inevitable loss of moisture.

A sample of approximately 50 pounds of lump coke was crushed to pass a 1-inch mesh sieve, and thoroughly sprayed with water. It was then mixed for some time and allowed to stand several hours. The moist coke was then placed on a sampling cloth, again mixed, coned, and divided into four parts, designated as C1, C2, C3, and C4. Each quarter was placed in a tared galvanised-iron pan, 22 by 26 inches, and immediately weighed. The coke was spread to a depth of about 2 inches.

Sample C1 was placed in an air-drying oven, and dried to constant weight at 30—35° C., and then pulverised and reduced to a 60-mesh laboratory sample, as in the usual standard method.

The other three samples were dried to constant weight on ordinary gas-heated hot plates at temperatures of 120°,

150°, and 200° C., respectively. There was an air space of one-fourth inch between the bottom of the pans and the hot plate. The temperatures were determined by inserting thermometers in the bed of coke near the bottom of the pans. The results obtained are given in Table V.

TABLE V.—*Results obtained by Heating 1-inch Lumps of Coke to Constant Weight on a Hot Plate at various Temperatures.*

Sample No.	Weight of sample. Grms.	Temperature of drying. °C.	Time required to reach constant weight. Hours.	Loss in weight. Per cent.
C1	6291	30—35	72	5·3
C1, 60-mesh	1	105	1	0·38
Total moisture in C1				5·7
C2	5105	120	2	5·9
C3	4909	150	2	6·2
C4	5923	200	1	5·9

The sample dried at 120° C. and the sample dried at 200° C. yielded 5·9 per cent moisture. These results were 0·2 per cent higher than that obtained with sample C1 which was air-dried before the moisture was determined by the standard method. The small differences in results with the various portions were probably due to unequal wetting rather than to the temperature of drying. Even the maximum difference is within the sampling error.

Summary.

1. Investigation shows that the influence of temperature, time, humidity of drying atmosphere, and fineness of sample on the determination of moisture in coke may be varied over a considerable range without affecting the result appreciably.

2. Oven temperatures ranging from 105—200° C. produced a maximum variation in moisture of not exceeding 0·3 per cent.

3. Coke can be dried to "constant weight" without any gain in weight taking place.

4. The circulation of air dried by sulphuric acid, through the oven atmosphere, as specified for coal analysis, is unnecessary, there being no measurable difference of results between circulating perfectly dry air through the oven and using in the oven the natural circulation of air from the room.

5. Moisture can be determined quickly and with adequate accuracy (±0·5 per cent) by simply heating to constant weight a large sample of lump coke, in any convenient oven, or on a stove, hot plate, or steam coil, at a temperature of 100—200° C.

Because of its simplicity and flexibility this method may be used advantageously at points when coke shipments are sampled.—*Technical Paper* 148, Bureau of Mines, Washington, U.S.A.

THE SCATTERING OF α-RAYS AS EVIDENCE ON THE PARSON MAGNETON HYPOTHESIS.

By DAVID L. WEBSTER.

THE essential feature of Parson's theory of atomic structure is the hypothesis that the electron is not a sphere, but a very thin ring, perhaps as much as $1·5 \times 10^{-9}$ cm. in radius, carrying a charge of negative electricity that circulates around the ring at a very high velocity ("A Magneton Theory of the Structure of the Atom," *Smithsonian Miscellaneous Collections*, 1915, lxv., No. 11). This gives it in addition to its electrostatic properties the *magnetic properties of a coil of wire carrying a current.* This hypothesis was used *very successfully* by Parson *in* explaining an extraordinary variety of chemical phenomena, and I have also found it useful as the basis of a theory of heat radiation that is consistent with Planck's law, and at the same time with the classical electrodynamical system and the numerous phenomena explained only by that system (D. L. Webster, *Proc. Am. Acad.*, 1915, l., 131). The magneton hypothesis, however, has not been generally accepted, one of the chief reasons, apparently, being that Parson's theory as he developed it calls for a large sphere of diffuse positive electricity, in which the electrons or magnetons, as he calls them, are free to move. In view of the epoch-making work of Rutherford and Darwin on the large-angle scattering of α-particles, this positive sphere hypothesis becomes untenable, and the natural impulse in giving it up is to give up the magneton hypothesis with it. In a recent paper by Langmuir (*Journ. Am. Chem. Soc.*, 1916, xxxviii., 2221) the theory is mentioned as attractive, but dismissed at once because of the positive sphere. If the positive sphere is essential to the magneton theory this action is necessary. If not, the sooner the two are separated the better.

But to introduce a nucleus, the assumptions of the theory must be changed, and there is ground for the opinion that the new assumptions are more radical than the old, which are, indeed, radical enough. In fact, G. N. Lewis, in a recent paper (*Journ. Am. Chem. Soc.*, 1916, xxxviii., 773), draws conclusions very much like Parson's from the chemical properties of the elements, but rejects the magneton hypothesis as a working basis, with a reference to a desire to avoid *à priori* assumptions. The purpose of this paper is therefore, first, to point out the possibility of substituting Rutherford's nucleus for the positive sphere, and, second, to make a critical examination of the status of the magneton theory when the nucleus is introduced.

According to Parson the positive sphere is "little more than a simple mathematical expression for the coherence and rigidity of the atom." With a nucleus exerting no forces but those of electro-magnetism the electrons would all fall into the nucleus. To hold them out the nucleus must exert some sort of repulsion that is not electrical, and varies faster than the inverse square of the distance. For any given distribution of density in the originally *assumed positive sphere it is obvious that there will be a* law of variation of this new force that will accomplish the same result so far as the positions of equilibrium of the magnetons are concerned. In the present state of our knowledge of these positions it is not yet time to attempt to derive from them the necessary law. In any case this non-electrical force, or "mystery force," as some have called it, is a new assumption to add to the theory. The question raised by the evidence of α-ray scattering is this:—Is the evidence for the magneton theory enough to justify all the assumptions involved now that one more is added? The hypothesis that the electron is magnetic was made to explain an attraction between two electrons at moderate distances that is demanded by chemical phenomena, and the phenomena of radiation demanded also a mystery force of repulsion at short distances between two *magnetons very similar to what is now assumed between* a magneton and the nucleus. Why, then, do we call the attraction magnetic? Why do we not make that also a mystery force, or, as Lewis does, simply assume one law by which repulsion and attraction alternate as one electron approaches another, and make no distinction of different parts of it, one as electric, another as magnetic, and a third as neither electric nor magnetic?

(NOTE.—The mystery force between magnetons might hold them alone, apart even with a nucleus exerting no mystery force. This suggests the possibility that the nuclear mystery force is unnecessary. But the electromagnetic theorem of no equilibrium in free space make this impossible, since even if the magnetons were all held in a rigid frame the whole frame would move until one of them struck the nucleus. Another question that might be asked is why the mechanism holding the electrons away

from the nucleus is not centrifugal action in orbits. There are two reasons against this, one the impossibility of stable orbits of the required types, and the other the absolute necessity of a static condition of the atom to explain such phenomena as the stability of shape of asymmetric molecules. The arguments on both of these points are given very clearly, both by Parson (*loc. cit.*) and in a somewhat different form by Lewis (*loc. cit.*), and especially in *Science*, N.S., 1917, xlvi., 297).

There are, as a matter of fact, several reasons for making this distinction. For one, let us consider for a moment the character of the groupings required by chemistry. In general, they are of two sorts, one a pair of electrons closely associated, and the other a very compact group of eight. (For the arguments on this point see Parson, *loc. cit.*, and also Lewis, *Journ. Am. Chem. Soc.*, 1916, xxxviii., 773). We never see a group of three, or any other odd number, unless, perhaps, in the rare compound H_3, which may not even exist at all. Now, suppose the law of force between two electrons were that of a repulsion at large distances and very small ones, with an attraction at intermediate ones. Then two electrons brought near each other would stay together in a pair. But a third one would also stick readily to them, or a fourth or a fifth, or any number. There would be no tendency to stay in pairs, and certainly no distinction for the number eight. But if the attractive force is that of a pair of doublets, like bar magnets, the pair once formed may be expected to orient themselves oppositely, and thereby cancel each other's attractive forces on a third one approaching from a distance. This means that the grouping in pairs indicates that the attraction is that of doublets, while the repulsions are both spherically symmetrical. The grouping in eights, as Parson has shown, is even stronger evidence in the same direction.

But even granting this, why is the doublet necessarily magnetic rather than electrostatic? One fact that makes this plausible, but *no more, is that magnetisation phenomena* mean that something in the atom must be magnetic. The assumption that this something is the electron is made highly probable by the data on magnetism collected by Parson, that show paramagnetism wherever chemical phenomena indicate a loose grouping of some of the electrons. This is exactly what one would expect if the electrons themselves are magnetic.

But even so, why should their magnetism be due to a circulation of the electricity rather than to magnetic poles? Here the phenomena of diamagnetism are important as evidence of the existence of inductive circuits in the atom, and the obvious instability of the sort of orbital motions that would be required if the electrons were of the classical type indicates that the circulation must be a continuous current. (For further discussion of this point see Parson, *loc. cit.*, and Lewis, *loc. cit.*). But even this does not prove that the inductive circuits causing diamagnetism are actually the same bodies as the electrons that cause paramagnetism and chemical bonds.

A phenomenon of the greatest importance in this connection is Barnett's effect of magnetisation by rotation. In Barnett's experiments (*Science*, 1909, xxx., 413; *Phys. Rev.*, 1915, vi., 239; 1917, x., 7) it was found that a piece of iron, cobalt, or nickel in rotation is magnetised in the absence of any external field. Now, if these elementary magnets are electrons moving in orbits, the gyroscopic properties of the orbits would make them behave in exactly this way. Moreover, as Barnett proved, the amount of magnetism to be expected can be predicted from the ratio e/m and the permeability of the metal, all references to the size of the orbit or the speed of rotation having cancelled out in the calculation. The experimental results show quantitative agreement, within limits of error, with the predicted values. Similar agreement was obtained for the inverse effect, rotation by magnetisation, in experiments begun later by Einstein and de Haas (*Deutsch. Phys. Gesell. Verb.*, 1915, xvii., 8, 152).

But as we have seen above, and as Barnett says in his latest paper, the assumption of a discrete particle of electricity in an orbit seems untenable, and a continuous current is preferable, provided it will have the proper gyroscopic properties. Now such properties are not a mathematically necessary accompaniment of all forms of translational mass, and the quantitative agreement with the gyroscopic properties of a revolving electron is by no means obvious. The only way to make definite statements on this point is to develop the mathematical theory of the electro-magnetic mass and gyroscopic properties of the magneton. This has been done by the present author (*Phys. Rev.*, 1917, ix., 484). It is found to involve not only a treatment of the electro-magnetic forces in an accelerated or rotating magneton, but also the internal forces that hold it in shape. On these latter forces we have no very certain data. But making the most plausible assumptions *à priori* it is found that formulæ for the mass and gyroscopic properties in terms of the charge and dimensions can be obtained, and that these formulæ make the gyroscopic properties exactly those of a magnetically equivalent orbital electron of the classical type, and therefore exactly those required by the Barnett and Einstein-de Haas effects. This makes it highly probable that the elementary magnets of ferromagnetism, and probably of paramagnetism and chemical bonds also, are really magnetons.

Thus it appears that we can class the magneton hypothesis not as an assumption made *à priori*, but rather on the surer basis of a most probable deduction from the experimental facts. As such it cannot be lightly tossed aside even if the assumptions that go with it are somewhat complex. Consequently, it seems probable that the α-ray phenomena should not be taken as valid evidence against the magneton theory, but simply as evidence for the existence of the nucleus along with its non-electrical repulsion for magnetons. — *Journal of the American Chemical Society*, xl., No. 2.

ELECTRO-CHEMICAL POTENTIAL AND THE PERIODIC LAW.

By J. C. THOMLINSON, B.Sc.

A CURVE of electro-chemical potential in which we consider cæsium as most electro-positive, contains the elements cæsium to lithium as of Group I., and barium, strontium, calcium to magnesium of Group II., aluminium in Group III., and then chromium and manganese in Group V. and VI. Applied to the common and some of the rarer elements this is feasible from all accepted properties of the potassium group, and together with the solubility of the chromates of calcium and magnesium from those of the oxides RO, those already mentioned as following aluminium taking position the fact of the basicity the R_2O_3 oxides. Then the curve returns, and includes zinc and cadmium before iron, cobalt, and nickel, the whole seven elements having a similarity in their RO oxides in that they are soluble in alkalis, copper, which comes later, having the property developed in its RO oxide.

After the iron group there is hydrogen, a non-metal, placed suitably after tin and lead, before antimony and arsenic, to which it is electro-positive, forming hydrides with the latter.

Copper and mercury follow, are in adjoining groups, have R_2O and RO oxides, and silver is classed with these, with defined R_2O oxide.

The non-metallic metals which continue the scale of chemical potential, are silicon, carbon, and boron, the remainder are in the right-hand top corner of the periodic table, and are nitrogen, phosphorus, sulphur, iodine, bromine, chlorine, oxygen, and fluorine, the most electro-negative elements.

THE ASSOCIATION OF GREAT BRITAIN AND FRANCE.

(Industry and Economics).

The Association of Great Britain and France corresponds to its *confrère*, "L'Association France-Grande-Bretagne," on the other side of the Channel, which was founded with a view to making better known, among friendly countries, the ideals, and specially the economic aims of France, in order that true reciprocity, founded on mutual understanding, may be established.

The Association is a complement to the industrial side of many excellent societies which are already in existence, or are being formed with the object of binding us closer to our French Allies.

Its work commenced in April last, and since that date the efforts of the Management Committee have naturally been directed to obtaining a strong nucleus of membership, and it now counts among its supporters some of the most prominent firms and trade associations in the Kingdom.

It has been felt, however, that the time has come for the Association to have its own quarters, and an independent organisation in order to further its aims. It has been resolved, therefore, to appeal to that wider public of both men and women whose sympathies or interests are affected by the industrial, commercial, or agricultural intercourse of the two countries.

The subscription, two guineas, has been purposely kept low, and no entrance fee is charged, as it is felt to be of the first importance to collect a large and energetic body of members who will, at all events, lend their support, if they are unable to give their time and experience, for the common good of both countries.

All information regarding the Association may be obtained on application to the Secretary, Association of Great Britain and France, 39, St. James's Street, London, S.W. 1.

May we ask, through the hospitality of your columns, for a wide and prompt response to this appeal?

(Signed) James W. Lowther,
Moulton.

ORDER OF THE MINISTRY OF MUNITIONS.

Gas Works Retort Carbon, Coke Oven Carbon, and Pitch Coke.

The Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm Regulations and all other powers thereunto enabling him, hereby orders as follows:—

1. No person shall as from the date hereof until further notice use, purchase, or take delivery of any Gas Works Retort Carbon, Coke Oven Carbon, or Pitch Coke, except under and in accordance with the terms of a permit issued under the authority of the Minister of Munitions, or sell, supply, or deliver any Gas Works Retort Carbon, Coke Oven Carbon, or Pitch Coke to any person other than the holder of such a permit as aforesaid.

2. The order of the Minister of Munitions dated January 10, 1917, relating to Gas Works Retort Carbon is hereby cancelled, but such cancellation shall not affect the previous operation of that Order, or the validity of any action taken thereunder, or the liability to any penalty or punishment in respect of any contravention or failure to comply with the same prior to its cancellation, or any proceeding or remedy in respect of such penalty or punishment.

3. All applications for permits under this Order shall be addressed to the Controller, Non-Ferrous Materials Supply, M.S./R./C.L., Ministry of Munitions, 8, Northumberland Avenue, London, W.C. 2.

4. This Order may be cited as the Gas Works Retort Carbon, &c., Control Order, 1918.

April 19, 1918.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, March 21, 1918.

Sir J. J. Thomson, O.M., President, in the Chair.

Papers were read as follows:—

"*The Magnetic Storm of December 16-17, 1917, as Recorded at Kew and Eskdalemuir Observatories.*" By C. Chree, F.R.S.

The magnetic storm of December 16-17, 1917, was of very considerable though not outstanding magnitude. It commenced between eight hours and nine hours on the 16th, and had not wholly subsided before the afternoon of the following day. Attention is directed in the paper to the curves for the twenty-four hours commencing at eight hours on the 16th. The most active period of disturbance was between fifteen hours (3 p.m.) on the 16th and four hours on the 17th. A prominent feature in the curves was a succession of oscillations of periods averaging about twenty minutes. There were also, especially at Eskdalemuir, some very large short-period oscillations. The paper compares the oscillations recorded at the two observatories, and gives estimates of the rate of change of the magnetic elements during the most rapid movements. The amplitude and rapidity of the changes proved to be much greater at the more northern station. The paper also gives details of the magnetic "activity" throughout the twenty-four hours, as derived from readings of the curves taken at 4-minute intervals, and discusses some general questions relating to the measurement of "activity."

"*The Absorption of X-rays.*" By E. A. Owen.

1. The absorption coefficients of a number of substances for a radiation of wave-lengths $0·586 \times 10^{-8}$ cm. (the α-line of palladium) have been determined, and the values obtained confirm those of Bragg and Pierce in the case of elements used in common.

2. The atomic fluorescent absorption coefficient is proportional approximately to the fourth power of the atomic number of the absorber.

3. The following relation exists between the atomic fluorescent absorption coefficient, atomic number of the absorber, and the wave-length of the radiation absorbed $fa = CN^4\lambda^3$, where C is a constant over certain ranges, but changes abruptly at critical points. This relation is independent of the scattering coefficient; it refers only to the loss of energy of X-radiation by the production of corpuscular radiations and the fluorescent X-radiations that accompany them.

4. Calculations based on the above general relation show that the molecular total absorption coefficients of different substances observed by Auren with radiation of wave-lengths $0·35 \times 10^{-8}$ cm. may be deduced very approximately from the atomic total absorption coefficients obtained for different elements with radiation of wave-lengths $0·586 \times 10^{-8}$ cm. if the coefficient of scattering be assumed to have a constant value of 0·2 for all elements from hydrogen to bromine for both these radiations.

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS.

Ordinary Meeting, April 3, 1918.

Dr. S. Rideal, President, in the Chair.

Certificates were read for the first time in favour of Mr. Denys Richard Wood, F.I.C., and Mr. Herbert James Llewllyn Parker.

Certificates were read for the second time in favour of Messrs. Stanley Dixon, A.I.C.; John Frederick Briggs, A.C.G.I.; Robert Duncan Masson, F.I.C.; and John William Hinchley, A.R.S.M.

Mr. William Herbert Miles was elected a member of the Society.

The following papers were read:—

"*Determination of Phosphoric Acid in Bone and Blood Fertilisers.*" By W. REST MUMMERY, F.I.C.

The author has investigated Ullmann's method, and, with certain modifications described in the paper, states that it provides a rapid and accurate gravimetric method for the estimation of total phosphate in bone and blood fertilisers.

A few analyses are appended showing the distribution of phosphoric acid in various fertilisers of this class.

"*Deterioration of Lime on Keeping.*" By S. ALLINSON WOODHEAD, M.Sc., F.I.C.

The general results of the experiments are that powdered lime, if protected from rain and frequently turned, undergoes very marked change, much more so than the same lime if heaped and exposed to the weather. Powdered lime, if heaped in the open, undergoes very little change, due to the protecting layer of carbonate formed on the surface of the heap.

"*Volumetric Determination of Barium and a Method of Separation of Barium and Strontium.*" By JOHN WADDELL, B.Sc. (Lond.), D.Sc. (Edin.).

A method of determining barium is given which consists in precipitating it as chromate, and titrating the iodine liberated on adding potassium iodide with thiosulphate. A modification of the process by means of which any strontium precipitated with the barium may be removed is also described.

"*Dog-fish Liver Oil.*" By A. CHASTON CHAPMAN.

The author has prepared in his laboratory two specimens of oil from a large number of livers of the common dog-fish (*Squalus acanthias*). The so-called analytical "constants" of these samples are given in the paper as well as a number of colour reactions.

"*Estimation of Moisture in Acid Oils,*" By E. RICHARDS BOLTON, F.I.C., and CECIL REVIS, F.I.C.

Acid oils, particularly those derived from coconut or palm kernel oils, cannot be dried in a hot oven owing to loss of fatty acids.

The authors describe a method of drying these oils on a crimped coil of filter-paper *in vacuo* over a dehydrating agent, and state this method to be more rapid and accurate than the usual practice of drying on sand.

RÖNTGEN SOCIETY.

Ordinary Meeting, April 9, 1918.

Capt. G. W. C. KAYE, President, in the Chair.

PROF. Sir ERNEST RUTHERFORD delivered the first Silvanus Thompson Memorial Lecture. He dealt with the important advances in our knowledge of the constitution of matter, resulting from the discovery of X-rays in 1895. The following brief abstract indicates the scope of the Address:—

The discovery of the X-rays marks the commencement of a new epoch in physical science, for in the attempts which were immediately made to ascertain the nature of the unknown radiation, attention was directed to the study of radiation in general, and new phenomena were soon encountered.

A general investigation of the cathode rays and of the nature of the discharge of electricity through gases led to the discovery of the "electron," and to the putting forward of the "ionisation theory" by Sir J. J. Thomson. Townsend followed up the initial work by his theory of ionisation by collision, and O. W. Richardson investigated the emission of ions from incandescent solids. All this work was originally of academic interest solely, but within the last few years the practical applications have been shown to possess immense value. These include the production of detectors and amplifiers for wireless telegraphy, electrical rectifiers, and oscillators, by which radio-telephony across the Atlantic is now possible, and the Coolidge X-ray tube which is destined to play an important part in radiology and in pure science. From the outset X-rays and the phenomena of phosphorescence were generally thought to be connected, and Becquerel, while in search of "invisible" or X-radiations from certain phosphorescent salts, discovered the radio-activity of uranium compounds. The brilliant researches of the Curies, by which this discovery was followed, resulted in the isolation of the radio-active elements, polonium and radium. Numerous other radio-active elements were brought to light, and the chaotic condition which ensued was not reduced to order until the introduction of the transformation theory by Sir E. Rutherford. Difficulties regarding the periodic classification were overcome by Soddy, who applied the term "isotope" to substances occupying the same place in the Periodic Table, and which cannot be separated chemically but whose atomic weights may differ slightly.

With regard to the study of X-rays themselves no outstanding advances were made for some ten years after their discovery, when Barkla obtained evidence of the existence of "characteristic" radiations from experiments on secondary X-rays. The discovery led to the wave-theory of the X-rays, which was completely substantiated at later dates by the diffraction experiments of Laue, the Braggs, Moseley, and Darwin. Barkla's characteristic rays are thus shown to be of the same nature as the rays yielding bright line spectra in the case of ordinary light. The diffraction experiments led to the employment of the X-rays for two classes of investigation, in the hands of Prof. Bragg and his son, problems of crystal structure have been successfully attacked, while in the other direction the late Mr. Moseley has shown these phenomena to be a most powerful method of investigating the constitution of the elements. He showed that the critical property of an element was its atomic *number*, while its atomic weight was relatively of secondary importance. The important relationship between the frequency of the K or L series of characteristic rays and the atomic number of the element should be known as Moseley's law.

At the conclusion of the meeting the President presented to Sir Ernest Rutherford the first of the medals which will be given annually in commemoration of the Silvanus Thompson Memorial Lecture.

SOCIETY OF GLASS TECHNOLOGY.

Annual Report for 1917.

THE Council has much pleasure in presenting this its First Annual Report.

During the period between November 18, 1916, and December 31, 1917, 267 members were elected, comprising 57 Collective, 197 Ordinary, and 13 Student Members. Two of the elections became void owing to non-payment of subscription, whilst the Society lost one member by death, Mr. James J. Hirst, a member of the Council, of whom an obituary notice appeared in the July issue of the Journal.

The Council decided at its meeting on November 18, 1916, to publish a quarterly Journal, and appointed Dr. W. E. S. Turner as its Editor. It is a source of great satisfaction to the Council that the Journal has been so very favourably reviewed, has been received so well by members of the Society, and is gradually becoming known abroad. The Journal for 1917 contains, in addition to indexes, 36 pages of Proceedings and Reports, 19 papers comprising 238 pages of Transactions, and 300 Abstracts and Reviews occupying 176 pages. The Council desires to take this opportunity of expressing its thanks to the Abstractors for the valuable services they have rendered.

It has been the object of the Council to arrange, so far as possible, that the subjects deal with at the Society's meetings shall be of general interest and lend themselves to discussion. There is a limit to which such a scheme can be continued with success, but that limit depends in a large measure on members themselves. The suggestion of subjects by members would be welcomed by the Council; but more than this, the Council trusts that an increasing number of manufacturers will communicate papers on observations made in their works, and thus initiate discussions in which both the practical and scientific bearings of a problem can be treated. The Council desires it to be known that communications on glass technology are welcomed from members at home or abroad.

During the year the Council decided to establish a Library, and a sum of £20 was in the first instance set aside for the purchase of books, whilst the Secretary was authorised also to arrange for the exchange of the Society's Journal for that of other Scientific Societies. At the present time the Library receives the following periodicals by exchange:—"Journal of the Chemical Society," "Journal of Industrial and Engineering Chemistry" (2 copies), "Transactions of the Ceramic Society," "British Clayworker," "Bulletin of the Imperial Institute," "Proceedings of the Institute of Chemistry," "Journal of the Society of Chemical Industry," "Transactions of the Optical Society," "Illuminating Engineer," "Journal of the Institute of Metals," "Journal of the Iron and Steel Institute," "Transactions of the Faraday Society," "Engineering."

In addition, the Society obtains by purchase or gift, "The Clayworker" (American), "The Pottery Gazette" (2 copies), "The Optician," "Die Keramische Rundschau," "Die Tonindustrie Zeitung"; whilst through the courtesy of the Department of Glass Technology, Sheffield, the following additional periodicals are available for reference:—"Sprechsaal," "Die Glashütte," "Die Glasindustrie," "Die Zeitschrift für Instrumentenkunde," "Transactions of the American Ceramic Society."

The total number of volumes in the Library to the end of December, 1917, was 71, with a number of pamphlets. The Council hopes that an increasing use will be made of the Society's Library by members. It would also welcome the gift of any books or periodicals bearing on glass technology.

In the early part of the year the Society was invited to appoint representatives to attend a joint Conference of Scientific Societies on Refractories Research. Mr. S. N. Jenkinson and Dr. W. E. S. Turner were appointed by the Council to represent the Society. At a later stage the President was invited and accepted a position on the Organising Committee set up by the Conference.

The income of the Society during 1917 was £482 13s. 6d., towards which contributions of £25 from Messrs. Lewis and Towers and £5 5s. from Messrs. E. Youldon, Ltd., were generously made. The cost of printing and distributing the Journal amounted to £393 12s. 11d., and other expenses brought the total to £499 10s. 9d., leaving a deficit of £16 17s. 3d. For a first year's working the Council believes the position is satisfactory, and that the deficit will be converted into a surplus at the end of the present year. Last year nearly 90 per cent of the Society's income was devoted to the work of publication and to general printing, and in view of the continued increase in the cost of paper and printing it is necessary that a considerably augmented income should be obtained. Every member can be of assistance in making the position of the Society more financially sound by engaging actively in propaganda on behalf of the Society and helping to increase its membership. In keeping with the importance of the Society its annual income should rather exceed than be below £1000.

Looking back over the period of fourteen months which this Report covers, the Council is of the opinion that the Society has fully justified its existence. The attendance at meetings, especially in view of the difficulties of travel, has been very good, and only in two instances has it fallen below 60. At the Society meetings there has grown up a feeling of common interest amongst members and a willingness to share information which are new to the industry. Especially would the Council express its gratification at the courtesy which several members of the Society have shown in throwing open their works to members on the occasion of meetings in the vicinity. All these things bespeak a happy future both for the Society and for the British glass industry.

NOTICES OF BOOKS.

Science and its Functions. By ALAN A. CAMPBELL SWINTON, F.R.S., M.Inst.C.E., M.I.E.E., M.I.Mech.E. Reprinted from the *Journal of the Society of Arts.* London: William Clowes and Sons, Ltd.

THIS most interesting Address was delivered at the opening meeting of the 164th Session of the Royal Society of Arts on November 21, 1917. The lecturer showed how all material progress of mankind has been due to increased knowledge of science, and traced the development of such knowledge from the times of primitive man to the present day, pointing out how one by one the epoch making discoveries have brought about the most stupendous advances in civilisation. He laid due emphasis upon the essential unity of pure and applied science, and showed how science has been potent in actually creating wealth by increasing productivity, while the ethical value of scientific work was not ignored. It is to be hoped that a wide circle of readers will profit by the Address, which is an admirable example of the cogent and temperate exposition of the great advantages to be gained by a due recognition of the importance to the nation of scientific knowledge and work.

Answers to Questions on the Flotation of Ores. By OLIVER C. RALSTON. Washington: Government Printing Office. 1917. Pp. 30. Price 5 cents.

THE *Bureau of Mines constantly receives inquiries* concerning the application of flotation in the treatment of ores or mixtures of ores, and although the answers to some of them could be found by searching the literature of the subject, in other cases practical information is difficult to obtain, and hence it seemed advisable to issue in the form of a bulletin the answers to such questions as were most frequently asked or were particularly important. Twenty-four questions are considered, and concise and authoritative answers are given to them, from which engineers can learn what types of ores can satisfactorily be treated by flotation methods, which are the most important methods from a commercial point of view, and also much information as to practical details, the cost of running flotation machines, and the causes and remedies of certain difficulties. No detailed accounts of plants and processes are included, nor is the theory of flotation discussed, and the bulletin aims only at giving direct answers to practical questions on the application of a method which is now being extensively used.

Estimation of Manganese in Steel.—The volumetric determination of manganese in steel, useful where a quick and ordinarily accurate test can be applied, when due attention is paid to the personal factor in the estimation, that one is aware of all incidental causes conducive to error, causes urgent attention to be drawn to the fact that if the filtering medium, asbestos, contains tungsten the result may be low; if any of the products of reaction pass through the filter-pad the acid result too high.—J. C. THOMLINSON, B.Sc.

CORRESPONDENCE.

VOLUMETRIC DETERMINATION OF MANGANESE.

To the Editor of the Chemical News.

SIR,—Noting the article on this subject in the CHEMICAL NEWS (vol. cxvii., p. 157), it is important to point out that inaccuracy in volumetric manganese estimations in steel when using sodium bismuthate is likely to occur through the sensitiveness of this method of oxidation to catalytic activation, in which the mass action results contribute to greater inaccuracy than likely to occur in either using sodium arsenite or $K_2Mn_2O_8$.—I am, &c.,

J. C. THOMLINSON, B.Sc.

SILICA BRICKS.

To the Editor of the Chemical News.

SIR,—In reply to the letter in the CHEMICAL NEWS (vol. cxvii., 167), if I may, without impropriety, mention two of my own books, I suggest that E. L. B. will find much of what he requires in "Refractory Materials—their Manufacture and Uses," by A. B. Searle (Griffin), and "The Clayworker's Handbook," by A. B. Searle (Griffin).

I shall be glad to assist him further if he cares to write to me, as I have spent the greater part of my professional life in dealing with bricks, &c., made of silica and allied materials.—I am, &c.,

A. B. SEARLE.

The White Building,
Fitzalan Square, Sheffield.

SILICA BRICKS.

To the Editor of the Chemical News.

SIR,—In answer to your correspondent, "E. L. B.," Searle's "Refractory Materials" gives full information on the above subject. Recent volumes of the *Transactions of the Ceramic Society* (Dr. Mellor, Stoke-on-Trent, Hon. Secretary) contain some very valuable and up to date information on this subject.—I am, &c.,

D. J. PINKERTON.

MISCELLANEOUS.

Prince Lichnowsky's Disclosures.—We understand that Messrs. W. H. Smith and Sons are preparing some three million copies of a pamphlet entitled "Guilty," containing a summary of Prince Lichnowsky's memoirs, by C. A. McCurdy, M.P. It is desired that these should be widely circulated, and employers are asked to distribute copies amongst their staffs and workpeople. For this purpose a supply will be sent carriage paid. Application should be made to Messrs. W. H. Smith and Sons, 186, Strand, W.C. 2.

The Strontia Process for the Recovery of Sugar from Beet-sugar Molasses.—It was pointed out in an article by Mr. Richard K. Meade, which appeared in the CHEMICAL NEWS (vol. cxvii., p. 126), that the present time is undoubtedly most opportune for introducing this process into this country In America this is already being done, and it is to be hoped that Great Britain will not fall behind in this respect. In this connection attention may be called to the advertisements of the Bristol Mineral and Land Company, Ltd., which have appeared in our recent issues. With sufficient supplies of strontium sulphate there should be no difficulty in establishing a lucrative strontium industry in England, and British chemical manufacturers will be well advised to take advantage of this opportunity.

New Method of Silvering Mirrors.—In the *Journal of the Optical Society of America*, a new and very valuable publication from the point of view of those interested in optical matters, Mr. Otto Stuhlmann, jun., describes a new method of making mirrors, applicable in the case of any metal, and to any material, varying from glass to paper. It is described as a distillation method, and the principles are simple, though the apparatus needed is a little complex. Briefly, the process is as follows:—To produce a silver mirror on, say, glass, a horizontal silver wire is heated to incandescence by means of an electric current, and the glass to be silvered is placed about 1 inch below it. The whole apparatus being in a vacuum, the wire is drawn at a uniform speed backwards and forwards across the glass, which is covered with a uniform coating by the descending metallic vapour. With small objects, such as galvanometer mirrors, a row can be arranged under the wire and treated simultaneously, the operation being completed in about one minute after the necessary vacuum has been obtained. It is claimed that either opaque or semi-transparent mirrors can be produced with equal ease, the thickness of the coating being determined very simply by the time given. Seeing the great difficulty there is in getting really good mirrors by chemical processes, it would seem worth while to give this new method a trial.—*The British Journal of Photography*, xlv., No. 3017.

TO comply with Regulation 8 (b) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Assistant Chemists wanted at once for Works Laboratory. Must be experienced in the Analysis of Ferrous and Non-ferrous Alloys, Gas, Coal, Water, and Oil.—Write, Box 246, Sell's Ltd., 168, Fleet Street, London, E.C. 4.

Assistant wanted for Laboratory Work in Explosives Factory near Southampton. Previous experience not essential. No person resident more than ten miles away or already employed on Government work will be engaged.—Apply, stating age, salary required, and experience (if any), to Box 89, care of Judd's, 67, Gresham Street, London, E.C. 2.

Chemical Laboratory Assistants (Lady) are required at a Gunpowder Factory. Applicants must have had a good education, including training in Elementary Science.—Address, "Superintendent," care of James Willing, Ltd., 125, Strand, London, W.C. 2.

ELEMENTARY CHEMISTRY.—Lecture Assistant and Demonstrator required. Knowledge at least equal to Inter. B.Sc. standard. Suitable for Student preparing for Final B.Sc., Exam., either a woman, or a man (ineligible for Military service). Salary £100, and free tuition.—Apply, PRINCIPAL, Birkbeck College, Breams Buildings, E.C. 4.

Junior Assistant Chemist required in the Laboratory of an Engineering Works in the South of England. Good knowledge of Theoretical Chemistry, with some experience in Analyses, desirable. No one need apply who has been passed for Military service in a higher grade than Class B 2 or Grade III. Give particulars of age, training, and salary required.—Address, E. W., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Metallurgical Chemist wanted by Sheffield firm to take charge of shift on 7-ton Heroult furnace. Must have first-class experience with Carbon and Alloy Steels.—Address, S. F., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted for the Laboratory of large Chemical Factory, well-trained and experienced Analysts. Accurate and systematic workers required.—Address, C. B., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

WOMEN CHEMISTS, with University training or its equivalent, required for ANALYTICAL WORK at salary of £175 per annum, in Government Department in South of England. Previous experience in Technical Analysis not necessary. Annual and sick leave allowed. Other women chemists employed. Salary to be increased to £200 per annum at end of six months if services found to be satisfactory.—Address, C. W., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

THE CHEMICAL NEWS.

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SPECIAL NOTICE TO SUBSCRIBERS.

We regret to announce that the recent paper restrictions will compel us for a period, until we can secure our usual supply of paper, to publish the Chemical News fortnightly instead of weekly.

The price will not be altered, except as regards the subscription price, which, until further notice, will be calculated at £1 for fifty-two numbers, or *pro rata*.

Subscribers will please note that the respective expiration dates of their subscriptions will be extended accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their extended subscription periods.

The next issue (No. 3048) will be published on May 24th.

THERMOSTATS.

By W. N. Ray, M.A., and J. Reilly, M.A., D.Sc.

Change of temperature affects the values of most physical and chemical constants. In many cases the effect is a large one, as, for example, with the electrical conductivities of solutions and rates of chemical reactions. It is therefore important in such cases to carry out the determinations at a fixed temperature, and to record the temperature at which each value of the constant was obtained. A change of temperature of 0·001° C. will alter the density of most liquids by about one in the sixth place; so that if densities are to be measured with this degree of accuracy the temperature must be maintained constant to 0·001° C. throughout the determination. Constancy to this extent is the best that can be obtained at present, and is only possible at temperatures within a few degrees of the room temperature, and preferably above it. An examination of the literature of such a subject as the electrical conductivities of solutions shows that results are recorded in various cases for 15° C., 18° C., 20° C., and 25° C.; when values are given for two or three of these temperatures there is less objection to raise, but in many cases results are shown for one temperature only, and there is no agreement as to what this temperature should be. Since we are able to obtain most accurate temperature regulation when the temperature is a few degrees above the room temperature it would clearly be of great advantage to fix a standard thermostat temperature so that it would always satisfy this requirement; there are few laboratories in Europe where the temperature remains below 15° C. throughout the year, while in many tropical laboratories the average room temperature is nearer 30° C. The adoption of a uniform thermostat temperature of 25° C. in Europe and 35° C. in tropical countries with determinations at both temperatures when possible would be of considerable value.

Thermostats for these temperatures consist of large baths of water or other liquid which are kept well stirred, while the temperature is regulated by gas or electrical heating controlled by some form of thermo-regulator. The advantage probably is with electrical heating as far as regulation of temperature is concerned.

It is often useful to have a rough instrument, especially in commercial laboratories. A metal capsule containing liquid, the expansion of which moves the top of the capsule and thence, either mechanically or electrically, cuts off the source of heat, furnishes one example, while a bimetallic strip which bends on heating gives another which can also be used at temperatures besides these in common use. Ostwald considers that spirals made from a band of two metals of as different expansibilities as possible rolled together might be suitable even for sensitive thermo-regulators, especially if connected with an electro magnetic regulator.

One form of thermostat which has proved very satisfactory in practice consists of a tank of copper 60 cm. long by 40 cm. broad and 40 cm. deep, and therefore holding nearly 100 litres of water. To prevent as far as possible loss of heat by radiation and so reduce the effect of variation in the external temperature, the sides are usually lagged with a layer about 3 cm. thick of some such non-conductor as slag wool.

No thermo-regulator is really satisfactory in a room whose temperature varies considerably. No lagging device will adequately compensate for external variations. If a thermostat is in an underground cellar of fairly constant temperature and free from draughts, lagging may be a positive disadvantage, as when the temperature of the bath is on the high side it takes all the longer to cool. In working fairly near the air temperature there is not much chance of the bath falling much below the required temperature, in which case only would the lagging come in useful. Also for high temperature thermostats, *e.g.*, for microscopical preparations, it is usually more important that the temperature does not exceed a certain amount, in which case lagging would be a disadvantage. Thus, while efficient lagging of the bath is often very useful it is difficult to generalise about its utility.

At the top of the two longer sides are plate-glass windows 15 cm. high and 60 cm. long to enable readings to be taken of objects completely immersed; the glass is sometimes cemented in position, but is better fixed by means of a metal frame fastened with screws to the metal tank, and with a layer of sheet rubber on each side of the edge of the glass, between the latter and the metal; such joints are water-tight, and the glass is more easily replaced when necessary (Cumming, *Trans. Faraday Soc.*, 1912, vii.).

When gas heating is used the bottom must, of course, be left unlagged; with electrical heating it can be protected in the same way as the sides. A constant level of the type used on water-baths may be employed, and should be adjusted so as to keep the level about 3 cm. from the top of the thermostat; at ordinary temperatures it is hardly necessary; it is sufficient to add some water every four or five days. A small drain-cock in one corner of the bottom is very useful for cleaning and emptying purposes. A less convenient but considerably cheaper arrangement can be made of a copper tank enclosed in a wooden case with a second wooden case, allowing a space of 2 or 3 cm. between the two; this space is filled with sawdust, cork, or other convenient insulator.

For the thermostat to be efficient, vigorous stirring is essential; good results have been obtained by using a bar passing lengthways along the bottom of the bath, and carrying six small paddles 5 cm. by 4 cm., and attached to a short arm which passes through a hole drilled in the bar and is held in position by a thumbscrew. The bar runs in vulcanite or metal bushes, which are secured to brass rods so as to be capable of vertical adjustment by means of clips fastened at the top of the bath; the height of the bar is adjusted so that the paddles just clear the bottom.

It is perhaps conducive to quieter running to have the bushes fastened to the sides of the bath near the bottom,

especially since the vertical adjustment is rarely used after the initial setting. The stirrer is driven either by means of grooved pulleys and a belt or by means of toothed wheels and a chain. In either case it is advisable to use large pulleys or wheels. Twisted tape makes a satisfactory belt which will last for months. A deep groove on the pulleys prevents the belt from slipping off, while the use of large pulleys stops belt-slip under a heavy load. With toothed wheels the teeth should be cut and not pin teeth, since the latter wear out quickly. Chains of the kind used in pianolas are used, but these stretch after a time, and then make a considerable noise as they slip on to the teeth; for this reason the use of belts is preferable in spite of the greater chance of breakage. The upper pulley is fixed by clips to the edge of the bath, and so can be moved along to take up the slack in the belt. *The spindle of this pulley is connected by a spring* coupling to a one-tenth horse-power motor fitted with worm reduction gear. Instead of the spring coupling, a pulley and a belt drive may be used, while the worm reduction gear may be replaced by the back wheel of a bicycle, the axle of the wheel being clamped firmly into a heavy retort stand. One belt passes from the motor round the rim of the wheel, while the other passes round that part of the hub between the chain-wheel and the spokes. The speed of the motor is regulated by means of a lamp resistance, or in the case of an alternating current by the use of a choking coil, so that the paddles make about 100 revolutions per minute. Small paddles with rapid stirring are found to be most effective.

The efficiency of various types of gas thermo-regulator has been investigated by Lowry (*Journ. Chem. Soc.*, 1905, T., 1030). *He found that with a large regulator of* the Ostwald type containing about 250 cc. of a 30 per cent solution of calcium chloride, the temperature of the bath showed periodic variations amounting to 0·05° C. in amplitude, and having a period of twenty minutes. Variations of the gas pressure affected the mean temperature of the bath to a large extent, but the effect is less with more sensitive regulators. A drop in the temperature of the room was found to increase the amplitude of the temperature variations.

Lowry designed two types of regulator which gave much more satisfactory results; the bulb of one was a fluted cylinder, while that of the other was a spiral. The constants of the best example of each type were as follows:—

	Fluted.	Spiral.
Dimensions	8 × 2 ins.	8 × 6 × 1 ins.
Volume	150 cc.	500 cc.
Movement of mercury	1 mm. for 0·017° C.	0·006° C.
Amplitude	0·010° C.	0·008° C.
Period	7 mins.	2 mins.

With both these regulators, after the initial period, the flame merely trembled and the temperature showed no marked oscillations. When gas heating is used the best results are obtained with a low and steady gas pressure; about 3 cm. of water is a convenient gas pressure to use, and this can be readily attained by the use of the gas pressure regulator described by Joseph (*Journ. Chem. Soc. Proc.*, 1914). The gas from the main enters through a thin walled rubber tube, which passes between a fixed bar and the hinged bar of a telegraph sounder. The thin rubber tube is connected by means of a T-piece to a large bottle, and to the side tube of a filter-flask which contains some 40 per cent sulphuric acid. The neck of the filter-flask is closed by a rubber stopper with two holes; through the smaller hole passes a glass tube with a platinum wire sealed in at the end and containing some mercury; the *platinum wire dips into the acid and so makes contact* with it. The other hole carries an open tube 1 cm. in diameter, with the lower end dipping into the acid; in this tube is placed the other contact made adjustable by passing it through a large cork resting on the top of the open tube. The telegraph sounder is in series with these two mercury contacts and with a battery giving about 6 volts. *When the gas pressure in the apparatus rises, the* acid is forced up in the wide tube and so completes the circuit; the electro-magnet then comes into operation and pinches the rubber tube, cutting off the gas supply as long as the pressure remains high. A lead weight placed on the bar of the sounder is an advantage in reducing the amplitude of the pressure oscillations. The large bottle takes up small variations of pressure, and from here the gas passes to the thermo-regulator, a T-piece serving to connect in a water manometer which indicates the gas pressure. When the apparatus is properly adjusted the fluctuations of pressure are less than a mm., even when the gas pressure in the main is as high as 25 cm. of water.

For long runs it is very advisable to further purify the gas by washing through either silver nitrate or a mercury salt (if a bubbler is used a large "capacity" must *follow) or other washing medium, otherwise the surface of* the mercury in the regulator soon becomes too dirty to be really good.

Many different types of thermo-regulator have been devised. Feild (*Journ. Am. Chem. Soc.*, 1914, xxxvi., 72) describes one which depends on the change in vapour pressure of ether, and which was capable of maintaining a bath of 350 litres at 30° C. with an accuracy of 0·01° C. to 0·005° C. for several days at a time. This form is not so sensitive as the toluene regulator described below, but it has the advantage of adapting itself to change of temperature of the bath with great rapidity, and therefore may prove useful when large or sudden changes in the external temperature are unavoidable. The apparatus consists of a U-tube closed at one end, having a threeway stopcock at the bend and a stopcock at the open end of the tube. *Two platinum wires are fused in the open side of the tube.* Dried ether and air are confined in the closed side of the tube by a column of mercury, and the increase of vapour pressure of the ether causes the mercury to make contact with the upper platinum wire, and so to shut off part of the heating circuit by means of a relay. The regulator is adjusted by the addition or removal of mercury, the air in the open arm is replaced by carbon dioxide and the tap is closed. Mercury is then poured above the tap and a rubber stopper is inserted. The threeway cock is also closed by a rubber tube and a pinchcock.

The Lowry pattern thermo-regulator is one of the most satisfactory; this, as mentioned above, is made in two forms: one a spiral closed at the upper end and connected at the lower with a narrow vertical tube rising out of the thermostat; the other consists of a series of *flattened bulbs* one above the other; the top bulb is sealed to a narrow tube, one end of which passes to the bottom of the lowest bulb, and the other projects above the water. The object of these particular forms is to expose as large a surface as possible, so that the liquid in the *regulator will follow the small changes in the tem*perature of the bath with as small a lag as possible. The narrow tube which projects above the surface is expanded to about 1 cm. in diameter, and has a side tube sealed on; the top of the wide tube is closed with a rubber stopper carrying an angle tube drawn out to a fine capillary; the end of the capillary is cut off or ground square, and passes down into the narrow tube. The angle tube and the side tube of the regulator are connected by an H-tube with a glass tap in the middle which acts as a by-pass. The upper tube of the H is connected to the gas pressure regulator and the lower tube to a micro burner, such as is used in the apparatus for the electrolytic detection of arsenic. The by-pass is adjusted so that the gas which passes this way is almost sufficient to maintain the temperature of the bath at the required value; very little gas then passes through *the regulator, with the result that the amplitude of the* temperature oscillations is small and the mercury is not so readily fouled by sulphur in the gas. (If the gas contains much sulphur it should be passed through a soda-lime tube). The liquid used in the regulator should have a large coefficient of expansion and a low density and specific heat; toluene is very generally used. The

regulator is filled in the following manner:—The toluene is first distilled, and is then repeatedly shaken with mercury to remove sulphur compounds, so that a clean mercury surface left in contact with the toluene will remain clean. The end of the regulator is closed with a stopper carrying a glass tube with a tap in it, and the side tube is connected by way of a tap to the water-pump. The regulator is exhausted and the tap is closed; the regulator is then inverted, the tube placed under toluene, and the tap opened so that some of the toluene enters; the tube is then again exhausted and some more toluene admitted. This operation is repeated several times until the apparatus is full; mercury is then added so as to nearly half fill the lower bulb, and the excess of toluene is removed. The regulator is then placed in the bath at the right temperature, and mercury is added or removed by a capillary tube. The final adjustment is made by replacing the rubber stopper and raising or lowering the capillary tube. A side tube is sometimes added containing a space filled with mercury into which projects a metal screw passing through a threaded hole in a round steel nut cemented on to the end of the tube; by turning the screw the position of the mercury can be very quickly adjusted so as to give the required temperature; the arrangement does not commend itself for very accurate work, and is likely to lead to small chance variations of adjustment which might not be noticed until too late. Two thermometers are required, one a sub-standard reading from $-10°$ to $50°$ C., each degree being sub-divided into tenths, so that temperatures can be obtained accurately to $1/100°$ C. and estimated by means of a microscope to $1/500°$ C., and a Beckmann thermometer. The two thermometers are fixed in the bath so that the points on the scales corresponding to the required temperature of the bath are as near to the surface of the water as is consistent with convenience of reading. The temperature of the bath is then adjusted to that required as indicated by the sub-standard thermometer, the readings being made with the aid of a small microscope and the necessary corrections being applied. The temperature on the Beckmann thermometer is then read, and in future the bath is always adjusted to correspond to a fixed point on the Beckmann thermometer; the latter adjustment can always be made correct to 0·001° C., although the actual value of the temperature is not known to the same degree of accuracy. In general, it is more important to get a steady temperature than to aim at any definite reading.

Whitaker's modification of thermo-regulators for gas consists in cutting off the gas by the mercury just at the top of a capillary tube, which rises from the bulb. A little well is ground at the top of the capillary, the angles of the bottom being as low (*i.e.*, as nearly horizontal) as is compatible with ensuring that the mercury will trickle back every time. The cut-off tube must approach very near indeed to the bottom of the well (say one-sixteenth up). The end of this is ground off internally at an angle estimated to be approximately tangential to the mercury globule where it touches it, thus disturbing and deforming it as little as possible. Ostwald lays great importance on the shape of the end of the inlet pipe. He considers it better to cut off the tube at right angles to the axis, so that it is shut off by a very small rise of the mercury and opened again by a corresponding small fall. Mane and Marquis have devised a simple and easily regulated thermostat (*Comptes Rendus*, 1903, cxxxvi., 614). Their instrument maintains a constant temperature to within two or three hundredths of a degree. It is composed of a cylindrical enamelled iron vessel of 15 litres capacity filled with distilled water. The vessel is placed inside a vessel of slightly larger dimensions, and the space between is filled with sawdust. The bath is heated electrically by means of a platinum wire, and the current regulated with the aid of a rheostat. The agitator is worked by a small electric motor. The constant temperature is maintained by means of a thermo-regulator consisting of a large glass cylinder filled with acetone or other liquid. The liquid selected should have a sufficiently large coefficient of expansion to give the apparatus a suitable sensitiveness. The expansion of the liquid causes the level of a mercury column to vary in the proximity of a platinum point. The current necessary to establish an electric circuit for the make and break is furnished by an auxiliary pile. It acts as a relay which connects the heating current.

For electrical heating the apparatus can be arranged conveniently thus:—The bath, stirring gear, and thermometers remain as before; as heaters two hot-point immersion heaters are used capable of taking 2 or 3 ampères at 100 volts; one of these replaces the by-pass in the gas-heated arrangement, the other is operated by the thermo-regulator. The former is connected to the mains with a choking coil or lamps in series to regulate the current, so that by itself this heater will keep the temperature just below the required value; instead of the heaters, carbon filament lamps may be used. The Lowry thermo-regulator has a thick platinum wire sealed into the bottom, making contact with the mercury inside. The other contact is a platinum wire mounted on a thin brass rod on which a screw thread is cut, and with a head having a milled edge at the top; the screw moves through a nut cemented into the top of the regulator and provides an easy method of adjustment. The side tube of the regulator is closed with cotton-wool. The regulator is in series with two storage cells, a 2000 ohm sliding rheostat, and a Post Office standard relay; a current of a few milli-ampères is sufficient to work the relay, but to prevent sparking with consequent injury to the contacts a condenser of 0·5 microfarads is connected in parallel with the relay terminals; the condenser may be replaced by a pair of aluminium plates insulated by glass tubing and held together by two rubber bands; the plates are about 8 cm. by 10 cm., and are immersed in a beaker of distilled water (Browning and Symons, *Trans. Faraday Soc.*, 1915, xi., 60). The second heater is connected in series with the mains, a lamp resistance, and the relay, the contacts being again shunted with a condenser. When the temperature rises contact is made in the regulator; the current from the storage cells then operates the relay, breaking the contact in the heating circuit; when the temperature falls, the current in the relay ceases, the spring in the relay then pulls the arm back, and again makes the heating current.

Either of the above thermostats will keep the temperature steady to 0·001° C. for weeks, while for longer periods they can be relied upon to 0·002° C. For some purposes it is necessary to use a thermostat adjusted to some temperature between zero and the room temperature; the heating arrangements of the ordinary thermostat can then be replaced by a coil of thin walled copper tubing carried round the walls of the thermostat near the top; ice water is passed through the coil, and the temperature is controlled by a thermo-regulator working a relay which cuts off the supply of ice water by pinching a thin walled rubber tube (Browning and Symons, *Journ. Soc. Chem. Ind.*, 1914, 33), somewhat in the same manner as in the gas pressure regulator described above. The top of the thermostat may be covered with plate-glass cut in three strips for convenience in removing. Greater accuracy than 0·01° C. cannot be obtained at these temperatures. Morgan (*Journ. Am. Chem. Soc.*, 1911, xxxiii., 334) devised an arrangement for maintaining a small thermostat at any desired temperature between 0·1° C. and 90° C. to a few hundredths of a degree. The regulator has a U-shape, one arm of the U being 3 cm. in diameter and 15 cm. long, and closed by a tap with a funnel above it. A platinum wire is sealed in this side, and bends vertically down so as to reach a point about 1 cm. above that at which the tube narrows. The bend of the U-tube is a capillary of 0·75 mm. diameter; about 6 cm. above the bend this expands to a diameter of 4 mm., which continues to the top of the tube; to the end of the tube is fixed by means of a thumbscrew a threaded collar with a binding screw. A threaded brass rod 2 mm. in diameter passes through the collar and terminates in a

short stout platinum wire. Mercury is added to within 3 cm. of the top of the capillary, and then purified toluene is poured in to fill the larger side tube. The stopcock is left open while the temperature of the bath is roughly adjusted to the required value, and is then closed, the final adjustment being made by means of the threaded brass rod. The two wires from the regulator are connected to a 2-volt cell and a relay which will operate so as either to make or break the current in the main circuit. The connection in a P.O. standard relay can be made so as to produce either result. The main circuit may consist of D.C. current from the mains passing through a 32 C.P. lamp, and an electro-magnet arranged like the telegraph sounder, except that the brass bar is prolonged and has a weight of several kilogrms. attached to it, so that when no current passes the weight causes the other end of the bar to press upwards against a metal stop. Between the latter and the bar passes a thin walled rubber tube which is compressed so that no water can flow through it. The bath has an overflow so as to keep the water-level constant, and ice water or hot water from a reservoir giving a pressure head of 40 to 50 cm. passes into the bath through the rubber tube. At temperatures below that of the room the electric circuit is arranged so as to cut off the current and allow ice water to flow when the expansion in the regulator makes the current there. For higher temperatures the connections are arranged so as to break the main current, and cut off the hot water supply when the temperature causes the regulator to make the current in the relay. Thermostats to give exactly 0° C. are rather difficult to arrange. Since water just above 0° C. is less dense than that at 0° C. it is advisable to have a good supply of ice at the bottom of the tank. A false bottom of perforated zinc is therefore fitted 15 to 20 cm. above the bottom of the bath, and on this rests a rectangular perforated zinc box of such a size as to leave ample space for ice between it and the sides of the bath; the box forms the actual working space, and can be fitted with a stirrer, &c. When preparing the thermostat for use crushed and washed ice is packed on the bottom to a height of 15 to 20 cm.; the false bottom is then secured in position, and on this the rectangular box; the space between the walls and the box is then packed with lumps of ice up to the top; ice water is next run in to the desired level, and finely crushed ice is put in to a depth of 2 or 3 cm. in the top of the box and a plate-glass cover placed on the whole.

For high temperature an electric furnace is described by Waidner and Burgess (*Bull. Bur. Stand.*, vi., No. 2). It consists of a resistance furnace mounted vertically, and having two separate heating coils of platinum ribbon 0·01 mm. by 2 cm. wound on porcelain tubes with the turns so spaced as to allow the establishment of a uniform temperature over a considerable length of the furnace. A separate rheostat controls the current in each circuit. Temperatures are read by means of a platinum resistance thermometer, and it is possible, by adjusting the rheostats by hand, to maintain the temperature steady to a few hundredths of a degree.

WAR BREAD.

By EDMUND I. SPRIGGS, M.D.Lond., F.R.C.P.Lond., Senior Physician, Duff House, Banff; late Seniour Assistant Physician to St. George's Hospital and Dean of the Medical School.

Much has been written about the alterations in the look and the taste of our daily bread which have taken place in the last three years. With better knowledge and practice in mixing flours and making bread there is an undoubted improvement in the loaf in those parts of the country from which most complaint came. There are still, however, many people who believe that war bread is bad for them, and a larger number who, whilst admitting that it may be good for healthy folk, think that it is unsuitable for the sick. It may therefore be of advantage to review afresh the composition of war bread at the present moment, to inquire what evidence there is of its digestibility in health and disease, and to consider what profit the nation gains by its use as compared with that of the pre-war wheaten loaf.

The war bread of to-day is made from flour which consists for the main part of wheat so ground as to yield 90 per cent of the grain as flour. This means that some of the branny material of the outer part of the wheat grain, which was formerly separated and used for feeding animals, is now ground up fine and added, with the germ, to the flour. With this 90 per cent wheat flour is mixed a variable proportion, usually less than one-fifth, of flour made from other cereals, chiefly barley, rice, and maize.

We may consider in what degree, if any, the digestibility of the bread is affected by the inclusion, first, of a part of the finely-ground bran, and, secondly, of the flour of other cereals.

Effect of including larger Proportion of Grain.

A good deal of work has been done in the past upon the advantages or disadvantages of grinding into flour a larger or smaller proportion of the wheat grain (see J. M. Hamil, "On the Nutritive Value of Bread made from Different Varieties of Wheat Flour," published by H.M. Stationery Office, 1911), the main result being that the differences in nutritive value of the flours so obtained are not great, not, indeed, so great as the differences between flours made from varying samples of wheat. Judging from earlier work, therefore, we should not be surprised to find that a 90 per cent flour might contain as much nourishment as many samples of 70 per cent or 80 per cent flour.

Recently the Food (War) Committee of the Royal Society has, in a well conceived and wide research, compared the digestibility of 90 per cent flour with that of 80 per cent flour ("Report on the Digestibility of Bread," 3206). Observations were made upon four persons in London, four in Cambridge, and four in Glasgow, the diet being regulated and the excreta analysed. The experiments were directed in the different centres by Mr. J. A. Gardner, Prof. F. G. Hopkins, and Prof. Noel Paton respectively, assisted by skilled workers. The results showed that the "90 per cent" bread was well digested, 94·5 per cent of the nutritive matter of the whole diet being made use of by the body. With the "80 per cent" bread, 96·1 per cent of the food consumed was absorbed. These figures are averages of all the experiments. There was, however, a striking agreement in the figures from each individual. The proportion of the nitrogen absorbed from the food was 87·3 per cent with the 90 per cent flour, against 89·4 per cent with 80 per cent flour.

This research shows that the addition to the flour of the extra 10 per cent from the outer part of the grain had only a slight effect upon the digestibility of the diet, the absorption being within 1 or 2 per cent of what it was with 80 per cent flour. The subjects of the experiment were of varying physique, and they ate rather more bread than they were accustomed to take. When allowances are made for such alteration in diet it may be said that the only notable effect of the bread was an increase in the bulk of the motions. One subject, who said that brown bread had always disagreed with him, suffered from diarrhœa, and the experiment was discontinued. He recovered on bread made from Government regulation flour. This subject was the only one of the twelve who took beer, and the thought suggests itself that it would have been of interest to have gone on with the experiment and discontinued the beer.

These observations are in accordance with experience in Switzerland, where an 87 per cent flour is now used. Prof. E. Feer has recorded that the bread has produced no digestive disturbance in the children in a large hospital, and that when wholemeal flour was added to the milk of hand-fed children from the third month instead of white flour, no difference could be observed in the nutrition of the children or in their excreta (E. Feer, "Ueber die

Verwendung des Vollmehls in der Säuglingsernährung. und über das Vollbrot im Allgemeinen," *Corresp. f. Schw. Aerst.*, December 27, 1917; quoted from *The Lancet*, March 9, 1918, p. 379).

Effect of Addition of other Cereals.

The dilution of wheat flour with other cereals would not be expected to have an adverse effect upon digestibility. There is none of the cereals which are available—namely, barley, rice, maize, and oats—which is not, or has not been, the staple food of whole nations.

Two experiments on the point have been published recently. The writer and Mr. A. B. Weir compared in a young man the digestibility of white bread and war bread with breads made from two-thirds white flour and one-third oats, barley, maize, or rice (E. I. Spriggs and A. B. Weir, "The Digestibility of Bread made from Two Parts of Wheat, and One Part of Oats, Barley, Maize, or Rice," *The Lancet*, November 10, 1917). The subject took a fixed diet, each bread being eaten with it for three days at a time, and the excreta were demarcated and analysed. All these breads were found to be palatable and were as nourishing as bread made from white wheaten flour, 95 to 96 per cent of the total nutriment being absorbed in each case.

In its newly published report the Royal Society Committee records observations on the digestibility of bread made from four parts of 80 per cent wheat flour and one part of maize flour. The bread was eaten by seventeen people, of whom twelve were also the subjects of the experiment with the 90 per cent wheat flour. Of the five new subjects four were boys aged eight, nine, twelve, and thirteen, and one was a man of fifty-five of poor digestion. At one centre the subjects did not find the maize bread so easy to eat as that to which they were accustomed, and some complained of flatulence. At another centre flatulence was not noticed, and one subject ate 2¼ lb. of the bread daily without discomfort. The analytical results of the observations were in no way dubious; they showed that the bread was as digestible as that made from wheaten flour.

In a further study under the direction of Mr. Gardner breads made from four parts of 90 per cent wheat flour and one part of a mixture of barley, maize, and rice, also of barley and rice alone, were eaten by forty-seven munition workers for one or two months. The workers were weighed each week, and their comments recorded. There was an average increase of weight. No flatulence or diarrhœa was complained of, and some of the workers who had suffered from constipation, and one who was liable to diarrhœa, were better while taking the bread.

We may therefore conclude from all these observations that the dilution of wheat flour with other cereals in the proportion hitherto used is in no way harmful. The use of potato in bread was not investigated in these experiments, but it may be assumed safely that such bread also is well digested. Indeed, much of it has been eaten with appreciation and without complaint.

Nature of Complaints.

The symptoms which are most commonly mentioned and attributed to war bread are a feeling of fulness, flatulence, looseness of the bowels, or constipation. It may be noted, in the first place, that a feeling of fulness and flatulence are the two commonest symptoms of indigestion of all kinds. They are likely to occur with any change of food, from dietetic errors unconnected with bread, from overwork or many other causes, and are not of consequence unless they persist. In view of the experimental data given above it appears that such symptoms cannot be ascribed to indigestibility of the ingredients from which war bread is made. If they arise from the bread at all they are more likely to be due to unskilful baking or insufficient chewing. War bread makes good toast, and for some types of weak digestion it is an advantage to toast it, as was, indeed, the case with pre war bread. The second complaint made is of mild disturbance of the bowels, chiefly looseness, though some of the subjects of the experiments with maize bread complained of constipation. On the whole, war bread appears to be a little laxative as compared with pre-war bread. This is probably an advantage to the nation. Constipation is, unfortunately, too common on the modern diet of civilisation, and is in many people a source of ill-health.

The Royal Society's report gives some observations in which the same bread as was supplied to the canteen above referred to was eaten by twenty-five patients, including some advanced cases, observed by Dr. G. B. Dixon and Dr. E. G. Glover, in two sanatoria. Three of the patients disliked the bread and preferred ordinary bread, but in none was there evidence of digestive disturbance. War bread has also been eaten by patients with many forms of indigestion without any complaint being made that was not made with white bread. Experience shows that the number of those who complain of war bread includes a good proportion of nervous folk who would in any case be complaining of something. Indeed, Prof. Feer says that in Switzerland only neurasthenics and hypochondriacs complain. We do not go so far as that, for we recognise at least two other classes of complainers. First, those already mentioned, who ascribe to a particular article of food symptoms due to other causes; and, secondly, those who do not like war bread and confound their likings with their needs. Members of our profession, when consulted by those in the last class, may justly call attention to the following facts.

Benefits from Use of War Bread.

Since a great part of our cereals comes from abroad the delivery of bread to each household involves the buying of corn abroad and its transport to this country. Such corn has to be paid for in money or in credit, and each payment lessens our wealth at a time when every penny is needed to help us in our struggle. But more than that, wheat brought across the sea involves at the present time a loss of ships and of our sailors' lives, owing to the frequent sinkings by submarines. The use of home-grown cereals to dilute wheat flour reduces these losses. A further reduction is made by grinding all the wheat to a 90 per cent standard, for this alone, as the figures of the Royal Society's Committee show, gives a gain of 10 per cent of nourishment, and even when allowance is made for the use of millers' "offal" to feed animals, there is still a gain of 9 per cent of nourishment. That is to say, by using war flour we save at least 1 pound in each 11 that are spent, one wheat-ship in each eleven sunk, and one life of each eleven that are sacrificed to give us our daily bread.—*The Lancet*, April 29, 1918, p. 613.

ON THE ATOMIC WEIGHT OF TELLURIUM IN RELATION TO THE MULTIPLE PROPORTIONS OF THE ATOMIC WEIGHTS OF OTHER SIMPLE BODIES.*

By HENRY WILDE, D.Sc., D.C.L., F.R.S.

THE recent determination of the atomic weight of tellurium by M. R. Metzner (*Comptes Rendus*, June 13, 1898) affords me the opportunity of again directing the attention of savants to the present anomalous condition of theoretical chemistry, and to the obstacles that stand in the way of its future progress.

The experiments made by M. Metzner show for tellurium an atomic weight equal to 127·9 as the mean of one series, and 128·01 for the second series. These results indicate a nearer approach to the theoretical number 128, adopted by Dumas and other chemists, than any previously recorded.

* *Comptes Rendus*, 1898, Tome II.

The classical memoir of Dumas (*Comptes Rendus*, tome xlv., 709; xlvi., 951; xlvii., 1026) upon the equivalents of *simple bodies embodied all our real knowledge of the* numerical relations among the atomic weights until the publication of my own memoir on the origin of elementary substances (*Manchester Memoirs*, 1878, 1886, 1894), wherein the triads and other multiple relations of the atomic weights revealed by the illustrious Dumas were greatly extended. I also found that the common numerical difference between the atomic weights of the oxygen series and the alkaline-earth metals observed by Dumas was exactly paralleled by a common difference in the atomic weights of the halogens and alkaline metals of half the amount shown in the series of oxygen and alkaline-earth metals. This new relation only became manifest after the work of Dumas by the *discovery of rubidium and cæsium*, and by the adoption of the atomic weights of Cannizzaro.

The absolute parallelism of the positive and negative series of elements Hn and H2n, as seen in my table (*Comptes Rendus*, November 8, 1897), in their numerical, chemical, and physical relations, leaves no doubt that, for these four natural and best known series, the multiple proportions of their atomic weights represent the truth of nature. The small differences observable between the experimental and a few of the theoretical atomic weights, when distributed among the twenty-four numbers composing the four series, only amount to 0·0046 of the actual determinations.

The atomic weights *are also in much closer agreement* with experimental results than is the fundamental law of atomic heats formulated by Dulong and Petit for these same series. No one doubts the general accuracy of this law, because it does not hold good for carbon, boron, and silicon, or to fractional quantities throughout the whole number of the elements. Dalton's law of chemical combination in definite and multiple proportions was founded on approximations differing for the principal elements more than 30 per cent from later determinations (Dalton's "New System of Chemical Philosophy," 1827, ii., 352), and through the adoption of the atomic weights of Cannizzaro, these differences are largely increased.

I would also *emphasise the fact, hitherto ignored* by chemists, that as the atomic weights of the two positive series of elements, Hn and H2n, are the products of the large multiple numbers, 16, 23, and 24 respectively, correlated also by the common differences 4 and 8 with the large multiple numbers 46 and 48 of the two negative series of elements, the exact multiple proportions subsisting among these higher atomic weights have an immensely greater validity in determining the question of their being whole numbers of hydrogen, than when all the equivalents were compared directly with the unit or half-unit of hydrogen by Stas and the older chemists.

I have now the honour to bring before the Académie a new argument in favour of the exact multiple proportions of the atomic weights, which, while helpful to earnest students of the natural sciences, will be a permanent check to the pretensions of those chemists who set up their laboured approximations of the atomic weights as the absolute truth of nature and the measure of the power of future investigators.

In the memoir referred to, Dumas formulated the proposition that "in three simple bodies of the same natural family, the equivalent of the intermediate body is always half the sum of the equivalents of the two extreme bodies." This proposition, as will be evident, is the rigorous expression of the definite and exact multiple proportions of the atomic weights.

The first example of this law given by Dumas is the triad of sulphur, selenium, and tellurium, with the old equivalents, 16, 40, 64, equal to 32, 80, 128 of the atomic weights of Cannizzaro. Now, in the geometry of solids, we have a triad of numerical proportions similar to those found in the atomic weights, since a cone, sphere, and cylinder, of equal diameter and altitude, have the ratios of 1, 2, 3, respectively, and the intermediate body is half the sum of the two extreme bodies, as in the triad of sulphur, selenium, and tellurium. The mental attitude of *those chemists who make their determinations of the* atomic weights the absolute truth of nature, would therefore be strictly paralleled by that of an ingenious artist who should endeavour to prove, by mechanical means, the ratios of the cone, sphere, and cylinder, but, finding that after the expenditure of much time and labour the exact ratios, by weight and measure, could not be obtained, owing to the unequal density of the material operated upon and other causes, should set the results of his labours above the demonstrations of the geometer, and declare, in the hyperbolic language used by Stas respecting the multiple proportions of the atomic weights as modified by Dumas, that the exact ratios of the cone, sphere, and cylinder are "*a mere illusion, a pure hypothesis, absolutely* contradicted by experience" (*Bull. Acad. Sci. Belgique*, 1860, x., 212).

Applying the foregoing reasonings to the determinations of the atomic weight of tellurium by M. Metzner, and accepting the theoretical value of 128 as correct, it will be seen that M. Metzner, by taking the mean of the results of his first series of experiments with the sulphate, and making the final atomic weight 127·9, has hardly done himself justice, as the second series with telluric acid shows a mean atomic weight of 128·01. Moreover, three of the seven determinations made by M. Metzner show the actual theoretical atomic weight 128, which is the criterion of *the experimental results.*—*Memoirs and Proceedings of the Manchester Literary and Philosophical Society*, 1918, lxi., Part II.

ORDER OF THE MINISTRY OF MUNITIONS.

Fertiliser Prices, 1918.

The Minister of Munitions has made an Order dated April 30, and taking effect as from May 1, relating to superphosphate, sulphate of ammonia, and ground basic slag. The Order supersedes previous Orders relating to superphosphates of August 20, 1917, November 17, 1917, and March 28, 1918, as regards sales after May 1 for delivery after May 31, and regulates trade, fixes maximum prices, and equalises the cost of distribution of the fertilisers by rail or water throughout the United Kingdom.

The Order operates independently of the Fertilisers and Feeding Stuffs Act, 1906. The provisions of the Order as regards maximum prices chargeable do not apply to fertilisers sold for export (other than to Channel Isles or Isle of Man), sales of less than 14 lbs., sales for delivery prior to June 1, or sales of sulphate of ammonia for use in the manufacture of munitions or for industrial purposes.

Licences are required for the sale of fertilisers and for their dispatch under certain conditions. Makers, dealers, and users must render such returns as are required.

"Superphosphate" means superphosphate of lime, manufactured from mineral phosphates, but does not include basic superphosphate, bone superphosphate, dissolved bones, bone meal, bone compound, guano, or compound manures, and sulphate of ammonia used for manufacture of compound fertilisers is deemed used for fertilising and not industrial purposes.

The scheme for equalising costs of distribution is contained in the fifth schedule to the Order which provides for the opening by every maker or producer of the fertilisers of an account with the Government, wherein the Government is to be debited with the cost of carriage by rail or water incurred by the maker, and credited with a fixed sum of 12s. 6d. per ton (allowed for in the maximum prices fixed by the Order, and meant to cover the estimated average cost of distribution), the difference being borne by the Government.

Applications for licences relating to sales and consignments of superphosphates, ground basic slag, and sulphate of ammonia to be used as fertilisers, and communication

relating to the scheme for equalising costs of distribution should be addressed to the Food Production Department, Board of Agriculture and Fisheries, 72, Victoria Street, S.W. 1.

All other applications in reference to the Order and for licences for sale of sulphate of ammonia to be used in manufacture of munitions of war, or for industrial purposes, should be addressed to the Director of Acid Supplies, Ministry of Munitions, Explosives Supply Department, Storey's Gate, Westminster, S.W. 1.

April 30, 1918.

LIGHTING, HEATING, AND POWER ORDER, 1918.

In reply to a letter addressed to the Board of Trade on the subject of the above Order, the Registrar of the Institute of Chemistry has received the following answer:—

April 25, 1918.

Sir,—With reference to your letter of April 5, on the subject of the restriction on the consumption of gas and electricity imposed by the Lighting, Heating, and Power Order, 1918, I am directed by the Board of Trade to state that where consulting, analytical, research, and technological chemists and teachers and professors of chemistry are able to show that by reason of their professional needs, they have been unable to effect the economy prescribed by the Order, the Board will accept this as a sufficient explanation under Paragraph 14 of the Order, a copy of which is enclosed.—I am, Sir, your obedient Servant,

(Signed) HERBERT C. HONEY.

Paragraph 14 of the Order is as follows:—

14. Proceedings for infringements of Part II. of this Order shall not be instituted except by or by the direction of the Board of Trade or the Attorney-General. Before instituting any proceedings the Board of Trade shall call upon the person affected to give an explanation of the apparent excessive consumption, and the Board shall consider any explanation offered. Provided that it shall be assumed in any prosecution unless the contrary is proved, that such explanation was called for, and if offered considered before such prosecution was instituted.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, April 25, 1918.

Sir J. J. THOMSON, O.M., President, in the Chair.

THE Bakerian Lecture was delivered by the Hon. Sir CHARLES PARSONS, K.C.B., F.R.S., on "*Experiments on the Production of Diamond.*"

The paper alludes to some of the results of experiments described in papers by the author to the Royal Society in 1888 and 1907, more particularly to those on the decomposition by heat of carbon compounds under high pressure, and on the effect of applying pressure to iron during rapid cooling.

A description is given of experiments designed to melt carbon under pressures up to 15,000 atmospheres by resistance heating, and by the sudden compression of acetylene oxygen flame, also by the firing of high velocity steel bullets through incandescent carbon into a cavity in a block of steel.

Allusion is made to experiments on chemical reactions under high pressure and their results. The pressures occurring in rapidly cooled ingots of iron, and experiments bearing upon this question, are discussed. Experiments at atmospheric pressure and experiments *in vacuo* are described.

The main conclusions arrived at are:—That graphite cannot be converted into diamond by heat and pressure alone, within the limits reached in the experiments; that there is no distinct evidence that any of the chemical reactions under pressure have yielded diamond; that the only undoubted source of diamond is from iron previously heated to high temperature and then cooled, and that diamond is not produced by bulk pressure as previously supposed, but by the action of the gases occluded in the metal and condensed into the centre on quick cooling.

A list of about one-half of the experiments is given in the Appendix.

CHEMICAL SOCIETY.

Ordinary Meeting, April 18, 1918.

Prof. W. J. POPE, C.B.E., F.R.S., President, in the Chair.

THE PRESIDENT referred to the loss sustained by the Society, through death, of the following Fellows:—Leonard Ison Pitt (killed in action, July 30, 1915); Edward Francis; George Thomas Glover; Henry James Helm; William Joel Kemp; Joseph Price Remington; Alfred Gordon Salamon; Edward Cumming Thompson.

It was announced that the following Committees for 1918—1919 had been appointed by the Council:—

Finance Committee—Messrs. E. G. Hooper, G. T. Moody, Sir E. Thorpe, Sir William A. Tilden, and the Officers.

House Committee—Messrs. R. Messel, J. E. Reynolds, Alexander Scott, J. M. Thomson, Sir William A. Tilden, and the Officers.

Library Committee—Messrs. B. Dyer, W. Gowland, A. Harden, J. T. Hewitt, C. A. Keane, A. R. Ling, T. M. Lowry, J. M. Thomson (Chairman), Sir William A. Tilden, J. A. Voelcker (Editor), and the Officers.

Publication Committee—Messrs. A. Chaston Chapman, A. Harden, T. A. Henry, C. A. Keane, G. T. Morgan, F. L. Pyman, Alexander Scott, J. F. Thorpe, and the Officers.

Research Fund Committee—Messrs. E. C. C. Baly, F. H. Carr, D. L. Chapman, H. J. H. Fenton, F. S. Kipping, A. Lapworth, W. H. Perkin, Alexander Scott, J. F. Thorpe, W. P. Wynne, and the Officers.

Messrs. M. Schlaepfer, H. A. Thomas, and W. D. Craddon were formally admitted Fellows of the Chemical Society.

Certificates for election were read for the first time in favour of George Henry Rowland Barham, 74, Kensington Avenue, Manor Park, E. 12; Henry Aldous Bromley, The Willow, Cambridge Road, W. Wimbledon, S.W. 19; Joseph William Bell, 130, Manchester Road, Burnley; Albert Eric Cashmore, 32, Vicarage Road, Smethwick, BO., Staffs.; Hubert William Dailey, 19, Beverley Road, Anerley, S.E.; Arthur Broughton Edge, Tudor House, Maidenhead; Francis William FitzGerald, 128, Earlham Grove, Forest Gate, E. 7; Nalini Mohan Gupta, M.Sc., Panposh, B.N. Railway, India; Ernst Johannes Hartung, M.Sc., 9, Glendearg Grove, Malvern, Melbourne, Australia; Ban Lockspeiser, M.A., 21, Thornby Road, Clapton, E. 5; Edgar Newbery, D.Sc., The University, Manchester; Edward Chuston Powell, 39, Lombard Street, E.C. 3; Runar Ivar Olsson-Seffer, 1, Royal Exchange Place, Calcutta, India; Alan Speedy, 81, Borges Road, East Ham, E. 6; John Thomas, B.A., D.Sc., Solway Dyes Co., Humell Hill Works, Carlisle; Hubert Charles Siegfried de Whalley, 18, Brandram Road, Lee, S.E. 13; William Whyte, 98, Kirkmanshulme Lane, Longsight, Manchester; Samuel Walter Woolley, 58, North Hill, Highgate, N. 6.

A certificate for election has been authorised by the Council for presentation to ballot under By-law I. (3) in favour of William Jay Hale, University of Michigan, Ann Arbor, Michigan.

The first of the Hugo Müller Lectures was then delivered by Sir HENRY MIERS, F.R.S., who discoursed on "*The Old and the New Mineralogy.*" A vote of thanks to Sir Henry Miers for his lecture was proposed by Prof. H. E. ARMSTRONG and seconded by Sir WILLIAM A. TILDEN, acknowledgment being made by the Lecturer.

Informal Meeting.—The next Informal Meeting of the Society will be held on Thursday, May 16, after the conclusion of the formal business of the Ordinary Scientific Meeting to be held at 8 p.m.

Research Fund.—A meeting of the Research Fund Committee will be held in June next. Applications for grants, to be made on forms which can be obtained from the Assistant Secretary, Chemical Society, Burlington House, W., must be received on or before Monday, June 3, 1918.

All persons who received grants in June, 1917, or in June of any previous year, whose accounts have not been declared closed by the Council, are reminded that reports must be returned by Saturday, June 1, 1918.

The Council wish to direct attention to the fact that the income arising from the donation of the Worshipful Company of Goldsmiths is to be more or less especially devoted to the encouragement of research in inorganic and metallurgical chemistry. Furthermore, that the income due to the sum accruing from the Perkin Memorial Fund is to be applied to investigations relating to problems connected with the coal-tar and allied industries.

ROYAL INSTITUTION.

Annual Meeting, May 1, 1918.

SIR JAMES CRICHTON-BROWNE, M.D., F.R.S., Treasurer, in the Chair.

THE Annual Report of the Committee of Visitors for the year 1917, testifying to the continued prosperity and efficient management of the Institution, was read and adopted.

The Report of the Davy Faraday Research Laboratory Committee was read.

Twenty-three new Members were elected in 1917. Sixty-two Lectures and nineteen Evening Discourses were delivered in 1917. The books and pamphlets presented amounted to about 299 volumes, making with 513 volumes (including periodicals bound) purchased by the Managers, a total of 812 volumes added to the Library in the year.

Thanks were voted to the President, Treasurer, and Secretary, to the Committees of Managers and Visitors, and to the Professors, for their valuable services to the Institution during the past year.

The following gentlemen were unanimously elected as Officers for the ensuing year:—

President—The Duke of Northumberland.

Treasurer—Sir James Crichton-Browne.

Secretary—Colonel E. H. Hills.

Managers—H. E. Armstrong; Sir Wm. Phipson Beale, Bart.; Sir James Mackenzie Davidson; John A. Fleming; Percy F. Frankland; J. Dundas Grant; Donald W. C. Hood; H. R. Kempe; the Right Hon. Lord Kinnaird; Sir Charles Nicholson, Bart.; the Hon. R. C. Parsons; Edward B. Poulton; J. Emerson Reynolds; the Right Hon. Lord Rothschild; the Right Hon. Lord Wrenbury.

Visitors—K. A. Wolfe Barry; Sir William H. Bennett; John G. Bristow; John F. Deacon; Edward Dent; Sir James J. Dobbie; John A. W. Dollar; W. B. Gibbs; William H. Gow; W. A. T. Hallowes; Sir Alexander Pedler; Hugh Munro Ross; Joseph Shaw; John Strain; Sir Henry J. Wood.

INSTITUTE OF CHEMISTRY.

Extraordinary General Meeting, April 27, 1918.

AN Extraordinary General Meeting of the Institute of Chemistry was held at King's College, London, on Saturday, April 27, to consider matters submitted to them by the Executive Committee of the proposed British Association of Chemists, having in view the desirability of effecting the more complete organisation of properly trained and competent chemists.

The following resolutions were passed:—

I. That it is desirable that the Council modify the existing requirements of the Institute, in order to include as many chemists as possible in the Membership (Associateship and Fellowship) of the Institute, so far as such a course is within the provisions of the Royal Charter of the Institute.

II. That it is desirable that any Candidate who has complied with the following conditions be accepted as eligible to apply for admission to the Associateship of the Institute:—

That he has attained the age of twenty-one years, and either—

(*a*) That he has obtained a degree with first or second class honours in Chemistry (or other degree or diploma recognised by the Council as equivalent) after a three years' systematic day course, and (i.) has taken a further year's training in chemistry at a recognised University or College; or (ii.) has had two other years' approved experience (see Note) under a Fellow of the Institute or in a laboratory or works approved by the Council; or

(*b*) That he has obtained a degree with first or second class honours in Chemistry (or other degree or diploma recognised by the Council as equivalent) after a four years' systematic day course; or

(*c*) That he has obtained a degree with first or second class honours in Chemistry after training (by day or evening classes), and experience equivalent in extent and character, in the opinion of the Council, to the training and experience specified in the two preceding paragraphs;

Provided in every case that the Candidate has produced satisfactory evidence of training and examination in Physics, Mathematics, and an optional subject.

(NOTE.—One year may be accepted by the Council as sufficient where the approved experience in a laboratory or works has been acquired *subsequently* to the prescribed training in a recognised University or College).

III. That, until December 31, 1921, it is desirable that any candidate who can produce evidence satisfactory to the Council of having had a sufficient general and scientific education, and of having practised pure and applied Chemistry for not less than seven years, and who holds a responsible position, should be accepted as eligible to apply for admission to the Associateship of the Institute, provided that he has complied with the provisions of the Charter of the Institute with regard to age, general education, and scientific training—in Chemistry, Physics, Mathematics, and an optional subject—and that he has passed approved examinations in those subjects.

(NOTE.—In considering applications under this clause, the Council will expect candidates to produce evidence of having been trained and occupied in a manner which, in the opinion of the Council, is equivalent to fulfilling the conditions required of candidates admitted under II.*a*).

IV. That Candidates who have not complied with the conditions specified under II. or III. immediately above, or with the regulations adopted as a temporary (War) measure, be required to comply

with the Regulations adopted and published by the Council in July, 1917.

V. That it is desirable that the list of Institutions recognised by the Council for the training of chemists should be reconsidered with a view to its further extension.

VI. That it is desirable that local sections of the Institute be formed in important centres where a Membership of not less than forty can be assured, the main objects of such sections to be to maintain the interest of the Members in the general welfare of their profession, and to promote social intercourse.

VII. That it is desirable that steps be taken to revise the present system for the election of the Council, in order to give the general body of Members greater freedom of nomination and election, with a view to securing representation from different localities and from different branches of the profession.

The Council will now proceed to modify the constitution and Regulations of the Institute on the lines indicated.

With regard to elections to the Fellowship, and elections to the Associateship under the temporary (War) conditions, the Council will review its policy from year to year, immediately after the Annual General Meeting.

It is the intention of the Council to maintain the requirements for Fellowship at a decidedly high level. Every Associate will be required to produce evidence that since his admission, and for a period of three years therefrom, he has been continuously engaged in the study and practice of chemistry in a manner satisfactory to the Council, and that he has carried out original research of sufficient merit in the opinion of the Council, or that he has devised processes or inventions of sufficient merit in the opinion of the Council, or in special circumstances, that he is possessed of knowledge and ability equivalent, in the opinion of the Council, to having fulfilled the conditions specified above, otherwise an examination will be imposed.

Provisional local sections are in course of formation at the following centres:—Edinburgh, Glasgow, Gretna, Liverpool, Manchester, North-East Coast, and Yorkshire, and rules for such sections have already been drafted.

Committees will also be formed when necessary to represent the interests of special branches of the profession, the provisions for the registration of students will be reconsidered; steps will be taken towards closer co-operation between the work of the Institute and that of the universities and colleges; the question of extending the publications of the Institute will be reviewed; further endeavours will be made to bring before the public the importance of chemistry to the country, and generally to forward the interest of chemists in every way possible.

SOCIETY OF CHEMICAL INDUSTRY.
(Birmingham and Midland Section).
Thursday, April 18, 1918.

Dr. R. S. Morrell in the Chair.

The following paper was read and discussed:—

"*The Works Chemist and His Relation to Buying.*" By E. R. Canning (Birmingham).

The author pointed out that in every trade paper at the present time one was constantly reading as to the prospective increased importance of the chemist in industry. It was foreshadowed, moreover, that in the period of reconstruction the chemist must take a much more important position in industry than at the present time. He was satisfied that in manufacturing works of reasonable size the chemist was a real asset by reason of the economies he could make and improvements he could effect. Complaints were often made that the chemist did not adapt himself to the commercial side of business. He believed there was some justification for the criticism. A chemist need not be a commercial man, but it was most desirable that he should familiarise himself with questions of administration and costs. Chemists, with full qualifications, were frequently underpaid, and not sufficiently assertive so far as their financial interests were concerned. It was not always easy for a chemist to show to the management of works a financial return for his labours, but this could often be readily done if he co-operated with the buyer. The chemist needed to refer to formulæ and chemical matters in language more easily understood by the lay mind in a works, and, as a rule, it was a disadvantage to send out inquiries in their correct chemical descriptions instead of the common commercial names.

It was the duty of the higher management in a works, said the author, to see that the closest co-operation existed between the chemist and those responsible for general administration. The chemist had many difficult and abstruse problems, and he should have authority when occasion required to invoke the aid of a chemical consultant. He was satisfied that in a large works buying could not be carried on without the co-operation of the chemist. Many business systems laid down that for various articles required six separate competitive prices must be obtained. Mistakes might easily be made in purchasing; some articles seemed, on the surface, to show a price advantage; but in practice, or on analytical examination, this did not prove the case. Works managers and foremen were apt to adopt a conservative attitude with regard to purchasing. A new article was not reported on any too favourably if there were a danger of it causing trouble to the foreman. Frequently, without the careful attention of the chemist new lines offered were not investigated except superficially, and undoubtedly many works suffered because of the difficulty of investigating new varieties and methods. There were on the market many proprietary articles of merit and offered at a reasonable price; but there were others which were sold at a high price and out of proportion to their value. The chemist might exert a potent influence in dealing with the latter; there was scope for economies. Improved methods of output and the standardising of quality of certain commodities required in manufacturing processes were matters that came within the domain of the chemist. As an instance, the author mentioned that in the metal trades aquafortis was largely used. The same quality was turned out, generally speaking, to treat all kinds of work —whether a casting, thin stamping, good quality brass, with a high percentage of copper, or a low grade brass. There was room for investigation as to the qualities that should be used for different classes of metal. A system should be adopted to see that aquafortis was properly used out before a fresh lot was started upon. As to the use of sulphuric acid, it might be well to determine the amount of acid that should be used to a certain tonnage of tubing. The pickler on piecework should be prevented from using an excess of acid to get his work out. In the buying of glue, prussiate, soft soap, and oils the expert advice of the chemist might be invaluable.

Discussion.

The Chairman said in the purchasing of raw products the works chemist might be able to be of great assistance. It would be better if the works manager or foreman knew a little of chemistry, for he would then be able better to appreciate the value of the advice given by the chemist in relation to works processes. As to buying, it seemed desirable that chemists should be able rapidly to determine the quality of a substance that was offered for sale to a firm. Sometimes the option was of very short duration. If the information required was not speedily forthcoming the firm would say, "What is the use of having a chemist?"

Mr. G. H. Howse (Smethwick) suggested that where a works possessed a capable chemist it ought not, as a rule,

to be necessary to buy proprietary articles. Owing to the suspected waste of nitric acid for dipping, pickling, &c., in the brass trade the Ministry of Munitions were investigating as to what should be the effective strengths of acids for such work.

Mr. E. W. Smith (Birmingham Gas Department) said while it was desirable that works managers and foremen should have more chemical knowledge it was important that they, as chemists, should put their own house in order with regard to the junior chemists. It was quite out of the question to expect comparatively simple research work from them—the unfortunate tendency had been to make appointments on the basis of what appeared to be cheapness—and it was of the first importance that chemists and manufacturers should do all they could for the better training of junior chemists by allowing them time off for definite systematic study.

Mr. Fred C. A. H. Lantsberry (Birmingham Small Arms Co.) said if too much commercial knowledge were required from the works chemist the effect might be to prejudice the value of his effort in his proper sphere. Many men, in works laboratories, were not really chemists, and were unable to carry out rapid and reliable tests in relation to all sorts of works processes, &c. Further training was necessary. No difficulty should be experienced by the tactful chemist in working harmoniously with the works foremen; the latter's antagonism was not altogether surprising in view of the fact that the arrival of the works chemist often meant the beginning of a new *régime*.

Mr. F. R. O'Shaughnessy (Birmingham Tame and Rea Drainage Board) said rapid analysis by the chemist was often very necessary to meet the requirements of the commercial departments in relation to buying. The Midland industrial community did not sufficiently value the chemist, and the result was that there was much acid waste, in the sewers, from factories. A few years ago in the Birmingham district nitric acid was present in relatively large quantities, and there were hundreds of tons of sewage deposit containing 2½ per cent of copper. The position has since improved.

Mr. T. F. E. Rhead (Birmingham Gas Department) suggested that with the question of costs, in relation to materials used and to the working of plant, the chemist should be familiar.

Mr. F. H. Alcock (Birmingham) urged that a chemist was entitled to a portion of the profits his brains created; but frequently the chemist was not remunerated by his firm for big financial gains he had introduced.

In reply, Mr. Canning said it was clear that if competition were successfully to be met after the war there must be a closer co-operation of science and industry. Many firms would spend money wisely by occasionally consulting chemists who specialised.

SOCIETY OF GLASS TECHNOLOGY.

Annual General Meeting, April 17, 1918.

Mr. Frank Wood, President, in the Chair.

After the presentation of the Annual Report of the Society and the balance sheet, the election of Officers for the forthcoming Session took place.

Mr. Wood then gave his Presidential Address. He began by reviewing the state of the glass industry at present as compared with its pre-war condition. The industry could be divided into eight important manufacturing sections, namely:—(1) Table and decorative ware, (2) plate and window glass, (3) optical glass, (4) chemical and scientific ware, (5) electric bulbs, &c., (6) pressed ware, (7) common glass bottles and jars, (8) flint glass bottles and jars. In a brief review of the outlook in each particular section, the following remarks were outstanding:—In the table and decorative glass trade the British were supreme in pre-war days in quality of production, but owing to unfair competition and cheap labour abroad the output was almost negligible. The present shortage of labour was a severe handicap to this trade, but given three years of freedom of action and protected by a strong tariff, the table and decorative glass ware manufacturer would be in a strong unassailable position.

The plate and window glass trade has been well maintained during the war, and is developing. The position as to optical glass is hopeful, and care should be taken that the country is never again dependent upon supplies from abroad. The highly important branch of chemical and scientific glass ware was non-existent in this country before the war. The country was too indolent to realise its importance, and as Germany and Austria produced cheaply and well they ruled the markets. Now this type of glass ware can be produced in this country in bulk, and equal in standard to the best German, and protection is necessary to preserve this trade. The production of electric bulbs has developed enormously during the war, and the same may be said of pressed glass ware. Both branches need protection.

By far the largest section of the glass industry is the production of common glass bottles and jars. Manufacturers have risen to the occasion, and the help of improved machinery has supplemented output. The signs in this branch of the glass trade are very healthy. The same may be said for the flint glass and jar section.

The President then went on to appeal for united action in each section, both amongst masters and men. Each trade section should organise itself, and then federate with the other sections, so that the weaker sections would have the help of the larger. It would be a great disaster if small sections were neglected. The industry as a whole appreciated the assistance of the department of optical and glass ware munitions, and also of the Board of Trade, and this assistance would be of even greater value and more certain support would be given if all the sections were united.

After pointing out the valuable assistance rendered by the Glass Technology Department of the University of Sheffield to the glass trade, and after voicing a warm eulogy of Dr. W. E. S. Turner, the President stated that he had every confidence in the future of the glass industry. After a sleep of fifty years, broken at times by many bad dreams, it had at last awakened.

The next portion of the Address dealt with the needs of the glass industry as regards raw materials. Data had been gathered and was placed before the meeting by means of lantern-slides, showing the amount of each raw material used per annum in the industry. At the same time the purity of materials was discussed. The concluding portion of the Address was a valuable contribution to the study of devitrification in glass. As is well known, tank furnaces are subject to devitrification on a large scale, this devitrification being known as "dogging." The formation of "dog" in reason is good, as it serves to protect the tank bottom. "Dog" in excess is very bad, as it gives rise to many difficulties and causes losses in output. The two best methods of preventing the formation of "dog," which is chiefly calcium silicate, are—(1) to increase the proportion of alkali in the batch, (2) to increase the proportion of alumina. The second method is to be preferred, as an increase of alkali means an increased attack on the sides and roof of the tank and also the formation of a less durable glass. The addition of alumina not only helps to prevent "dogging," but it means less attack on the tank walls and the production of a more durable tougher glass. For dark bottle glass sufficient alumina may be added by mixing with every 100 parts of batch from 5 to 6 parts of ground red brick. For light green bottle glass ground felspar should be substituted for the brick. Specimens of glass, melted by Miss A. M. Jackson, B.Sc., were shown to indicate the beneficial effect of felspar on bottle glass.

The President closed with an expression of thanks to the authorities of the University of Sheffield for their kindness and courtesy to the Society.

Mr. G. V. WILSON, B.Sc., F.G.S., then read a paper entitled "*Notes on the Formation of certain Rock-forming Minerals in and about a Glass Furnace.*"

The paper was one of the most important ever read before the Society, and many of the results when applied in works practice will be of vital importance. By means of a large number of slides the author showed the formation of various types of crystals in glass. He then went on to deal with questions of the effect of heat upon glass, pots, and furnace blocks, and showed by a wonderful collection of slides and diagrams the varied effect of the different constituents of fire-clays upon the life and durability of a glass pot or tank.

A full discussion of the various changes which take place was given, and parallels with natural processes were drawn. A set of microscopic slides and a numerous collection of specimens enhanced the value of the lecture, which was followed by an animated discussion.

The next meeting of the Society will be held on May 15 in London.

CORRESPONDENCE.

SILICA BRICKS.

To the Editor of the Chemical News.

SIR,—*In reply to your correspondent, E. L. B., in the* CHEMICAL NEWS (vol. xvii., p. 157), I beg to say that I know of no authoritative work such as that for which he enquires, but if he should care to communicate with me personally I should be glad to supply him with such information as lay in my power.

In the event of his doing this, would he be explicit as to the kind of tests required?—I am, &c.,

JOHN JACKSON-GROVER,
Works Chemist, Fire-brick Works (M.G.).

24, South Road, Stourbridge,
April 25, 1918.

THE ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS.

To the Editor of the Chemical News.

SIR,—The attention of my Council has been called to a certain misapprehension which exists in the minds of the public as to the body entitled to speak on behalf of the chemical manufacturers of the United Kingdom. In this connection I would call attention to a paragraph in the Report of the Committee appointed by the Minister of Reconstruction to advise as to the procedure which should be adopted for dealing with the chemical trade, which reads as follows:—

"We are, however, of opinion that the Association of British Chemical Manufacturers is the most representative Association of the Chemical Trade at present in existence in this country, and that it does, generally speaking, represent the trade as a whole."

The address of the Association of British Chemical Manufacturers is 166, Piccadilly, W. 1.

Thanking you for giving publicity to this letter.—I am, &c.,

G. MOUNT, Secretary.

166, Piccadilly, London, W. 1,
April 26, 1918.

Paper Shortage.—Owing to the great and growing shortage of paper the public are requested to exercise the greatest economy, particularly in the matter of stationery. Much of the notepaper now in use is extravagant in size and quality.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxvi., No. 2, January 14, 1918.

Action of Hydrobromic Acid upon Cinchonine and its Isomers, Cinchoniline, Cinchonigine, and Apocinchonine.—E. Léger.—Skraup has shown that when HBr acts on cinchonine the substance $C_{19}H_{23}BrN_2O.2HBr$ is obtained. The author has further investigated this reaction, and also the action of HBr upon the isomers of cinchonine, and finds that two phenomena usually occur:—(i.) Addition of HBr. If, however, the four bases examined give the same compound with cinchonigine and apocinchonine another base, differing from hydrobromocinchonine is simultaneously produced; he suggests for it the name hydrobromoapocinchonine. (ii.) HBr also produces phenomena of isomerisation.

No. 3, January 21, 1918.

New Preparation of the Fatty Nitriles by Catalysis.—Alphonse Mailhe.—The author has recently shown that very good yields of aromatic nitriles can be obtained by the direct action of gaseous ammonia upon the ether salts of acrylic acids in presence of a catalyst, such as thoria heated to a temperature of 470—480°. Precipitated alumina gives the same result, and it has now been found that the method can be applied to the preparation of the aliphatic nitriles. The author gives the details of the preparation and yields of isovaleronitrile, butyronitrile, and propionitrile.

No. 4, January 28, 1918.

Action of Methylene Iodide upon 1.4-Dimethylaminopentene.—Amand Valeur and Emile Luce.—When a slight excess of methylene iodide acts at the temperature of the laboratory upon 1.4-dimethylaminopentene the product has the empirical formula $C_8H_{17}NI_2$. It behaves like an iodide of quaternary ammonium, and its structural formula appears to be $CH_2=CH.(CH_2)_3.N(CH_3)_2.CH_2I.I$. Thus a closed ring is not formed as is the case with iodine, but the methylene iodide adds itself on to the nitrogen, as with methyl iodide.

MISCELLANEOUS.

Royal Institution.—The Friday Discourse on May 17 will be delivered by Dr. A. B. Rendle, M.A., D.Sc., F.R.S., at 5.30 o'clock; the subject will be "The Story of a Grass."

The Lord Roberts Memorial Fund for Disabled Soldiers and Sailors.—(Patrons: H.M. the King and H.M. the Queen. President: Her Royal Highness the Princess Christian. Hon. Treasurer: Rt. Hon. Sir Frederick Milner, Bart., P.C. Organising Secretary, Extension Fund: J. G. Ketchen).—The Lord Roberts Memorial Workshops, situated in London and the provinces, are giving permanent employment to nearly 1200 men, disabled in the war by loss of limbs or wounds. The demand for greater provision for the increasing number of wounded, able and willing to undertake work, becomes more and more urgent; hence the inauguration of the Extension Fund for providing new buildings and plant. To help this fund a special appeal will be made in London and the suburbs during the week May 20 to 28, at hotels, shops, works, &c. No flags will be sold, nor will the collection be made in the streets, but the public will have the chance of filling model "Tanks" (made by the men in the workshops) with coins of the realm to aid this pressing, indeed imperative, work. Realising what these men have given up and suffered for us, should we not do all in our power to alleviate their sufferings and show our gratitude for their heroism?

TO comply with Regulation 8 (b) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Chemical Laboratory Assistants (Lady) are required at a Gunpowder Factory. Applicants must have had a good education, including training in Elementary Science.—Address, "Superintendent," care of James Willing, Ltd., 125, Strand, London, W.C. 2.

Chemist, Male or Female, wanted to carry out Will Test in Factory near Southampton.—Write, stating age, experience, and salary required, to Box 99, care of Judd's, 97, Gresham Street, E.C. 2.

Lady Assistant Chemist (wanted in Rugby district) who has passed either Inter. B.Sc., full B.Sc., or Inter. A.I.C. Examination; Organic and Inorganic Analytical Work. Organic includes large variety of Insulating and Electrical Engineering materials. Opportunity for progressive experience. Several Lady Chemists employed. No person already on Government work will be engaged.—Apply, giving training, copies of testimonials, to your nearest Employment Exchange, quoting No. A 5221.

Metallurgical Chemist for Controlled Works on North East Coast, with sound knowledge of the Analysis of Copper Alloys. Must have had experience with quick Electrolytic Methods of Analysis. The vacancy offers excellent post-war prospects to a really live man who is not afraid of work. No applicant will be considered under twenty-four years of age.—Write, giving full particulars of experience, stating age and salary required, to the nearest Employment Exchange, mentioning the CHEMICAL NEWS and No. A 5151. No one at present on Government work need apply.

Men or Women Chemists, with University training or its equivalent, wanted as Assistant Laboratory Chemists at an Explosives Factory. Apply in writing.—Address, "Chief Chemist," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, Assistant Assayer and Analytical Chemist for London Laboratory. State age and salary required.—Write, "Metal," care of Street's, 30, Cornhill, E.C. 3

Wanted, two or three Junior Lady Assistant Chemists for an Oil Laboratory. State qualifications and salary required to Box "Lady Chemist," care of Advertisement Department, Central News, Ltd., 5, New Bridge Street, E.C. 4.

Works Analytical Chemist required. One conversant with Soap Manufacture, Nicotine Extractions, and Agricultural and Horticultural Preparations. State full particulars and salary required.—Address, W. A., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

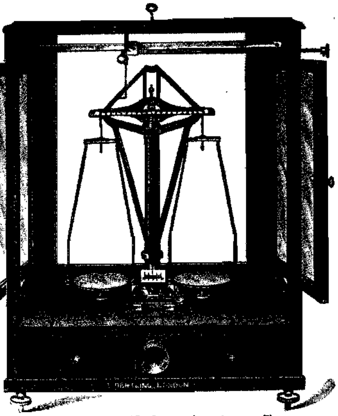
WOMEN CHEMISTS, with University training or its equivalent, required for ANALYTICAL WORK at salary of £175 per annum, in Government Department in South of England. Previous experience in Technical Analysis not necessary. Annual and sick leave allowed. Other women chemists employed. Salary to be increased to £200 per annum at end of six months if services found to be satisfactory.—Address, C. W., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

ST. DUNSTAN'S COLLEGE, CATFORD, S.E.

Wanted at once for this College, a JUNIOR LABORATORY ASSISTANT, male or female. Work: to have charge of Chemical and Physical Apparatus and to prepare Experiments; some knowledge of Chemistry and Physics is essential. Salary according to experience.—Apply to C. M. STUART, Head-master.

TOOTAL BROADHURST LEE COMPANY, LIMITED.

A Woman Graduate in Science is required for the Research Department, to prepare Abstracts of Records of Laboratory Work, to have charge of the Library, and carry out the clerical and confidential duties of Secretary to the Department.—Applications, stating salary required, and giving qualifications, testimonials, and references, should be addressed to "Dept. A. K.," 56, Oxford Street, Manchester.



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By JOHN CANNELL CAIN, D.Sc. (Manchester), Editor of the *Journal of the Chemical Society*; Examiner in Coal-tar Colouring Matters to the City and Guilds of London Institute; sometime Member of the Technical Committee, British Dyes Ltd. With 25 Illustrations. 8vo. 10s. net.

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A CLASS-BOOK of ORGANIC CHEMISTRY. By J. B. COHEN, Ph.D., B.Sc., F.R.S., Professor of Organic Chemistry, the University, Leeds. Globe 8vo. 4s. 6d.

THE PHŒNIX.—"The prime object of this book is for the use of senior science students in schools and for first-year medical students. . . . Experiments of a very useful nature are to be found throughout the book, making it of a practical as well as a theoretical value."

LABORATORY GLASS-WARE ECONOMY. A Practical Manual on the Renovation of Broken Glass Apparatus. By H. B. DUNNICLIFFE, M.A., B.Sc. Illustrated. Globe 8vo. Limp cloth. 4s. net.

NATURE.—"In this workmanlike little book he describes the processes he has developed, and explains how difficulties may be surmounted with success. Teachers in charge of chemical laboratories at home will find the volume very useful."

MACMILLAN and CO., Ltd., LONDON.

THE CHEMICAL NEWS

Vol. CXVII., No. 3048.

SPECIAL NOTICE TO SUBSCRIBERS.

We regret to announce that the recent paper restrictions will compel us for a period, until we can secure our usual supply of paper, to publish the Chemical News fortnightly instead of weekly.

The price will not be altered, except as regards the subscription price, which, until further notice, will be calculated at £1 for fifty-two numbers, or *pro rata*.

Subscribers will please note that the respective expiration dates of their subscriptions will be extended accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their extended subscription periods.

The next issue (No. 3049) will be published on June 7th.

THE PREPARATION OF INORGANIC STANNICHLORIDES.

By J. G. F. Druce, B.Sc

Although some double salts of tin have been known for a long time, very little systematic work has been done on them. It therefore seemed desirable to prepare and examine a series of stannichlorides of onivalent and bivalent metals. The preparation of most of the possible ones has been carried out by passing chlorine into solutions containing the metal chloride and stannous chloride.

In most cases it was found possible to vary the proportions of the two chlorides, but the most satisfactory results have been obtained by employing the quantities demanded by the general formulæ M_2SnCl_6 or $M''SnCl_6$.

Attempts have also been made to isolate the metal stannochloride first, but success in this direction has only been attained with magnesium, zinc, potassium, and ammonium. Magnesium and zinc stannochlorides were obtained anhydrous, whilst the potassium and ammonium compounds possessed two molecules of water of crystallisation. When these stannochlorides were dissolved in dilute hydrochloric acid and left exposed to the air, they oxidised more or less readily but not completely, for after several weeks the solutions gave a precipitate with mercuric chloride solution, indicating the presence of some stannous chloride.

Of the alkali stannichlorides the lithium salt appears to possess eight molecules of water of crystallisation. Von Biron (*Journ. Russ. Phys. Chem. Soc.*, 1904, xxxvi., 489) gives $Li_2SnCl_6.6H_2O$, and Chassevant (*Ann. Chim. Phys.*, 1893, xxx., 5) gives $Li_2SnCl_6 8H_2O$. The hygroscopic nature of many stannichlorides renders their isolation and purification somewhat difficult.

Sodium stannichloride was first prepared by Rosler by dissolving sodium chloride in a concentrated solution of stannic chloride (*Dingl. Poly. Journ.*, 1867, clxxxvi., 38). From his analyses he assigned the compound five molecules of water of crystallisation. The compound prepared by the new method is found to be identical with that obtained in the way he describes, but has six molecules of water of crystallisation.

The potassium, rubidium, and ammonium salts are all anhydrous, and are also quite stable in air and do not deliquesce.

The alkaline earth stannichlorides were difficult to isolate in a state of purity on account of their strong tendency to deliquesce. This is most developed in the case of the barium salt, which was never obtained pure in spite of repeated attempts to isolate it; discordant analytical results were obtained on the material used. Von Biron (*loc. cit.*) mentions that it could not be obtained from stannic chloride and barium chloride. The strontium salt was less deliquescent than the calcium salt and had four molecules of water of crystallisation, whereas the calcium salt was only isolated in the anhydrous condition.

The stannichlorides of magnesium, zinc, cobalt, and nickel had all six molecules of water to one of the salt. Cadmium stannichloride was only obtained in the anhydrous condition.

It was not found possible to prepare the stannichlorides of copper or lead by this method.

In estimating the percentages of the elements present in each salt standard analytical methods were followed except in the case of the alkali salts. Here it was desirable to recover the lithium and rubidium in the form of chlorides for future preparations. In these cases a slightly acid solution of the stannichloride (0·2 to 0·5 grm.) in about 60 cc. was saturated with sulphuretted hydrogen and allowed to stand for about an hour. The precipitate of stannic sulphide was filtered off, and when the filtrate was free from tin it was evaporated carefully to dryness in a small porcelain basin on a water-bath and then carefully heated below red heat for half-an-hour. The basin was cooled in a desiccator over sulphuric acid and weighed.

Nickel and cobalt were estimated electrolytically after the tin had been removed from solution as sulphide.

When those stannichlorides containing water of crystallisation were heated above 100° C. they lost in weight. If the temperature be raised much above 100° some hydrochloric acid accompanies the water driven off. Hence it seemed doubtful whether the water content of the salts could be accurately determined by heating in a steam oven.

Lithium Stannichloride, $Li_2SnCl_6.8H_2O$. — Lithium chloride (2·12 grms.) and stannous chloride (5·65 grms.) were dissolved to a clear solution in 30 cc. of dilute hydrochloric acid (1 part of concentrated acid to 3 parts of water). The solution was concentrated, but crystallisation did not take place on cooling and standing overnight. The hygroscopic solid which was ultimately obtained was found to be a mixture containing stannous tin (since it gave a precipitate with mercuric chloride solution), and much stannic tin (since the precipitate obtained on passing hydrogen suphide into the solution was decidedly yellow). Further experiment were made, but no stannous double salt has been prepared.

The bulk of the solid from the above experiment was redissolved in 30 cc. of dilute hydrochloric acid and chlorine gas was passed in until a drop of the solution no longer gave a precipitate with mercuric chloride. The solution was concentrated to about 20 cc. and placed in a desiccator over solid potash and calcium chloride. The crystals which separated out over-night were rapidly filtered off, drained, and dried on a porous tile in an empty desiccator.

This salt was found to be deliquescent and exceedingly soluble in water. On exposure to air the crystals first became opaque, and then the lithium chloride set free attracted moisture and the mass liquefied. The aqueous solution was not readily hydrolysed except by boiling for some minutes. On analysis:—

0·2053 grm.	gave	0·0630 grm. SnO_2;	Sn = 24·16	per cent.
0·2053 „	„	0·0493 „ LiCl;	Li = 3·93	„
0·1965 „	„	0·3461 „ AgCl;	Cl = 43·59	„

$Li_2SnCl_6.8H_2O$ requires—

Li	2·85
Sn	24·35
Cl	43·65
H_2O	29·15
	100·00

$Li_2SnCl_6.6H_2O$ requires—

Li	3·09
Sn	26·24
Cl	46·78
H_2O	23·89
	100·00

Sodium Stannichloride, $Na_2SnCl_6.6H_2O$.—It was not found possible to prepare sodium stannochloride by dissolving sodium and stannous chlorides in dilute hydrochloric acid and allowing the solution to crystallise. Invariably sodium chloride separated out first. When the mother-liquor was concentrated, more salt separated until finally there remained a solution of stannous chloride containing very little sodium chloride and some stannic chloride.

The stannichloride was obtained by dissolving 11·7 grms. of sodium chloride and 22·6 grms. of stannous chloride in 200 cc. of dilute hydrochloric acid. Chlorine was slowly passed in during four hours, and then the solution no longer contained stannous tin. The filtered solution was slowly concentrated and allowed to crystallise over-night. The crystals were filtered off, drained, and dried on a porous tile in an empty desiccator. The salt was slightly deliquescent, becoming damp on exposure to the atmosphere. It was somewhat more readily hydrolysed in aqueous solution than lithium stannichloride, but less so than the potassium salt. On analysis:—

0·5350 grm. gave	0·1607 grm.	SnO_2;	Sn = 23·65	per cent.
0·5501 „ „	0·1358 „	NaCl;	Na = 9·72	„
0·2697 „ „	0·4771 „	AgCl;	Cl = 43·75	„

$Na_2SnCl_6.6H_2O$ requires—

Na	= 9·48
Sn	= 24·45
Cl	= 43·81
H_2O	= 22·26
	100·00

Potassium Stannochloride, $K_2SnCl_4.2H_2O$.—This salt was prepared by dissolving 7·5 grms. of potassium chloride and 11·3 grms. of stannous chloride in 100 cc. of dilute hydrochloric acid. The solution was concentrated on a water-bath and on cooling deposited large white opaque crystals. These were collected and dried. Potassium stannochloride did not dissolve in water to a clear solution, but was immediately hydrolysed, the liquid becoming very turbid. The salt dissolved readily and completely in dilute hydrochloric acid. It did not deliquesce on exposure. On analysis:—

			Per cent.
1·0339 grm. gave	0·4777 grm. K_2SO_4;	K	= 20·72
1·0339 „ „	0·4141 „ SnO_2;	Sn	= 31·58
0·3877 „ „	0·5934 „ AgCl;	Cl	= 37·89
1·0339 „ lost at 105°	0·0993 „ H_2O;	H_2O	= 9·60
			99·79

$K_2SnCl_4.2H_2O$ requires—

K	= 20·80
Sn	= 31·74
Cl	= 37·86
H_2O	= 9·60
	100·00

Potassium Stannichloride, K_2SnCl_6.—This salt can be conveniently prepared from the above stannochloride and also from solutions of the two metal chlorides by chlorination. In one experiment 3·75 grms. of potassium chloride and 5·65 grms. of stannous chloride were dissolved in 80 cc. of dilute hydrochloric acid, and chlorine was passed in for two and a-half hours. The solution was then concentrated on a warm water-bath, and on cooling overnight deposited crystals which were filtered off, drained, and dried on a porous plate. The salt dissolved readily in cold water, but hydrolysed on warming, and also on standing, even below 20° C. A clear solution was always obtained when the salt was dissolved in dilute hydrochloric acid. Potassium stannichloride was quite stable in air and did not deliquesce. On analysis:—

0·6608 grm. gave	0·2853 grm.	K_2SO_4;	K = 19·25	per cent.
0·5883 „ „	0·2159 „	SnO_2;	Sn = 28·69	„
0·5033 „ „	1·0569 „	AgCl;	Cl = 51·99	„
			99·93	

K_2SnCl_6 requires—

K	= 19·20
Sn	= 28·74
Cl	= 52·06
	100·00

Rubidium Stannichloride, Rb_2SnCl_6.—A pure specimen of rubidium stannochloride was not obtained.

The stannichloride was prepared by dissolving 3·61 grms. of rubidium chloride and 3·39 grms. of stannous chloride in 50 cc. of dilute hydrochloric acid. The liquid became clear on warming. Chlorine was passed in until the solution no longer gave the test for stannous tin with mercuric chloride. The solution was then carefully concentrated, and on cooling deposited a mass of small crystals, which were filtered off, drained, and dried between sheets of bibulous paper. The salt dissolved easily in water, but the solution became cloudy unless hydrochloric acid was added to retard hydrolysis. The fine crystals did not deliquesce in the air. On analysis:—

0·4278 grm. gave	0·2108 grm.	RbCl;	Rb = 34·82	per cent.
0·4278 „ „	0·1294 „	SnO_2;	Sn = 23·83	„
0·1209 „ „	0·2182 „	AgCl;	Cl = 42·66	
			101·31	

Rb_2SnCl_6 requires—

Rb	= 34·02
Sn	= 23·63
Cl	= 42·35
	100·00

Ammonium Stannochloride, $(NH_4)_2SnCl_4.2H_2O$.—Stannous chloride (11·3 grms.) and ammonium chloride (5·35 grms.) were dissolved to a clear solution in 70 cc. of dilute hydrochloric acid by warming. This solution was allowed to cool slowly, and deposited large white crystals, which were filtered off and dried between sheets of bibulous paper. The crystals were easily fractured, and on heating lost water above 100° and were further decomposed at 265° without melting. They dissolved readily in water, the solution becoming turbid on warming. As in the case of the corresponding potassium salt, solutions showed the usual reactions associated with stannous compounds. On analysis:—

0·4643 grm. gave	0·2083 grm.	SnO_2;	Sn = 35·34	per cent
0·2828 „ „	0·4878 „	AgCl;	Cl = 42·68	„

$(NH_4)_2SnCl_4.2H_2O$ requires—

(NH_4)	= 10·85
Sn	= 35·68
Cl	= 42·64
H_2O	= 10·83
	100·00

Ammonium Stannichloride, $(NH_4)_2SnCl_6$.—Six grms. of ammonium stannochloride were dissolved in 20 cc. of dilute hydrochloric acid, and chlorine water was run in from a burette until all the tin was in the stannic state. For this purpose 85 cc. of the chlorine water used were required. The solution was carefully concentrated, and on standing deposited fairly large octahedral crystals of the stannichloride. This salt resembled the potassium salt in appearance and properties. Dilute aqueous solutions decomposed on standing more readily than concentrated ones. On analysis:—

0·3718 grm. gave 0·1526 grm. SnO_2; Sn = 32·34 per cent.
0·4231 „ „ 0·9925 „ AgCl; Cl = 58·01 „

$(NH_4)_2SnCl_6$ requires—

(NH_4)	=	9·82
Sn	=	32·30
Cl	=	57·88
		100·00

Calcium Stannichloride, $CaSnCl_6$.—No double salt of stannous and calcium chlorides was isolated. To prepare the stannichloride 5 grms. of stannous chloride and of calcium chloride were dissolved by warming with 80 cc. of dilute hydrochloric acid, chlorine was passed in until the liquid no longer contained stannous tin. The solution was then slowly concentrated to about 30 cc., but crystallisation did not occur. Crystals were ultimately obtained by placing the concentrated solution in a desiccator over calcium chloride and caustic potash. The salt was very deliquescent and was only obtained free from absorbed water by being kept for several days on a porous plate in a desiccator over sulphuric acid.

This hygroscopic character of the substance was attributed at first to the presence of admixed calcium chloride; but when excess of stannous chloride was used in the preparation the tendency to deliquesce did not seem to diminish, and thus it appears to be a property of the stannichloride. This view is supported by the fact that the analytical figures indicate a fairly pure compound.

Moreover, concentrated solutions which might contain barium stannichloride attract moisture with great avidity. When chlorine was passed into solutions containing barium and stannous chlorides until the latter was completely oxidised, concentration and subsequent cooling did not lead to the deposition of crystals. On one occasion, after a concentrated solution had remained overnight in a desiccator with sulphuric acid, some long colourless prisms appeared. However, they began to deliquesce immediately whilst being filtered off from the mother-liquor, and could not be satisfactorily dried on a porous plate in a desiccator.

Aqueous solutions of calcium stannichloride did not hydrolyse unless they were boiled for some minutes. On analysis:—

0·7048 grm. gave 0·2014 grm. $CaCO_3$; Ca = 11·43 per cent.
1·0449 „ „ 0·4058 „ SnO_2; Sn = 30·61 „
0·3940 „ „ 0·9113 „ AgCl; Cl = 57·22 „
99·26

$CaSnCl_6$ requires—

Ca	=	10·79
Sn	=	31·95
Cl	=	57·26
		100·00

Strontium Stannichloride, $SrSnCl_6.4H_2O$.—Several unsuccessful experiments were made with the object of preparing strontium stannochloride.

The stannichloride was prepared, but with some difficulty, in the usual way from 4·8 grms. of strontium chloride and 6·8 grms. of stannous chloride in 100 cc. of dilute hydrochloric acid, chlorine being slowly passed in during five hours. The solution was filtered and carefully concentrated on a water-bath until a scum began to form on the surface. The basin containing the solution was transferred to an empty desiccator to cool, and deposited long colourless needle crystals, which were rapidly filtered off, drained, and dried on a porous plate in an empty desiccator. The substance was less deliquescent than the calcium salt. It was very soluble in cold water and dissolved readily in 90 per cent alcohol. The aqueous solutions hydrolysed on keeping, unless one or two drops of hydrochloric acid were added, in which case they remained clear for several months. On analysis:—

				Per cent.
1·1597 grm. gave	0·4257 grm.	$SrSO_4$;	Sr =	17·51
1·1597 „ „	0·3532 „	SnO_2;	Sn =	24·00
0·2022 „ „	0·3519 „	AgCl;	Cl =	43·06
1·1597 „ lost at 105° C.	0·1706 „	H_2O;	H_2O =	14·70
				99·27

$SrSnCl_6.4H_2O$ requires—

Sr	=	17·84
Sn	=	24·17
Cl	=	43·31
H_2O	=	14·68
		100·00

Magnesium Stannochloride, $MgSnCl_4$.—The double salt was obtained by dissolving 4·2 grms. of magnesium carbonate in dilute hydrochloric acid (50 cc.), and mixing this with a solution of 11·3 grms. of stannous chloride in 70 cc. of dilute hydrochloric acid and concentrating to the crystallising point. On cooling colourless deliquescent crystals separated. They were quickly filtered off, and could only be dried satisfactorily by placing on a porous plate in a desiccator over sulphuric acid. On analysis:—

				Per cent.
0·8897 grm. gave	0·3637 grm.	$Mg_2P_2O_7$;	Mg =	8·93
0·8897 „ „	0·4578 „	SnO_2;	Sn =	40·54
0·2042 „ „	0·4052 „	AgCl;	Cl =	49·11
				98·58

$MgSnCl_4$ requires—

Mg	=	8·54
Sn	=	41·68
Cl	=	49·78
		100·00

Magnesium Stannichloride, $MgSnCl_6.6H_2O$.—Five grms. of the stannochloride were dissolved in 50 cc. of dilute hydrochloric acid, and chlorine was passed in until all the tin had been oxidised to the stannic state. The solution was then evaporated to a small bulk and allowed to stand over-night. The colourless crystals which were deposited were filtered off, drained, and dried on a porous plate in an empty desiccator. The salt was much less deliquescent than the stannochloride. Its aqueous solutions hydrolysed on boiling. On analysis:—

				Per cent.
0·3515 grm. gave	0·1090 grm.	$Mg_2P_2O_7$;	Mg =	6·77
0·3515 „ „	0·1207 „	SnO_2;	Sn =	25·82
0·2129 „ „	0·3915 „	AgCl;	Cl =	45·51

$MgSnCl_6.6H_2O$ requires—

Mg	=	5·25
Sn	=	25·60
Cl	=	45·85
H_2O	=	23·30
		100·00

Zinc Stannochloride, $ZnSnCl_4$.—Zinc chloride (4·5 grms.) and stannous chloride (7·5 grms.) were dissolved in 100 cc. of dilute hydrochloric acid by gently warming

The solution was concentrated to small bulk and deposited colourless crystals on standing over-night. These were filtered off and dried on a porous plate. They were not so deliquescent as the corresponding magnesium salt and the aqueous solutions were more stable. On analysis:—

0·4631 grm. gave 0·1149 grm. ZnO; Zn = 19·94 per cent.
0·4631 „ „ 0·2136 „ SnO_2; Sn = 36·34 „
0·3312 „ „ 0·5754 „ AgCl; Cl = 42·99 „

99·27

$ZnSnCl_4$ requires—

Zn	= 20·06
Sn	= 36·42
Cl	= 43·52
	100·00

Zinc Stannichloride, $ZnSnCl_6.6H_2O$.—Six grms. of zinc stannochloride were dissolved in 80 cc. of dilute hydrochloric acid and chlorine was passed in for four hours, when the salt was completely converted into stannichloride. The solution was evaporated down to small bulk, and on cooling it deposited colourless crystals. These were filtered off and dried on a porous plate.

Zinc stannichloride did not deliquesce in air. It dissolved freely in cold water, but was thereby slightly hydrolysed. Hydrolysis became more complete on warming. On analysis:—

0·7102 grm. gave 0·1087 grm. ZnO; Zn = 12·29 per cent.
0·7102 „ „ 0·2207 „ SnO_2; Sn = 24·43 „
0·4233 „ „ 0·7206 „ AgCl; Cl = 42·13 „

$ZnSnCl_6.6H_2O$ requires—

Zn	= 12·87
Sn	= 23·56
Cl	= 42·15
H_2O	= 21·42
	100·00

Cadmium Stannichloride, $CdSnCl_6$.—No stannochloride of cadmium has been isolated.

For the stannichloride 5·5 grms. of cadmium chloride and 6·7 grms. of stannous chloride were dissolved in 100 cc. of dilute hydrochloric acid, and chlorine was passed in for three hours, when the solution no longer gave the reactions for stannous salts. The solution was evaporated to very small bulk, but did not deposit crystals until it was kept for twelve hours in a desiccator over sulphuric acid. The very deliquescent crystals were filtered off, drained, and dried by placing on a porous plate in a desiccator with sticks of caustic potash. On analysis:—

0·5132 grm. gave 0·1756 grm. CdS; Cd = 26·61 per cent.
0·5132 „ „ 0·1711 „ SnO_2: Sn = 26·37 „
0·1439 „ „ 0·2410 „ AgCl; Cl = 47·74 „

100·72

$CdSnCl_6$ requires—

Cd	= 25·31
Sn	= 26·76
Cl	= 47·93
	100·00

Nickel Stannichloride, $NiSnCl_6.6H_2O$.—Nickel chloride (4·76 grms.) and stannous chloride (4·52 grms.) were dissolved in 80 cc. of dilute hydrochloric acid. The solution did not yield crystals of a stannochloride when evaporated to a small bulk. It was diluted again to 100 cc., and chlorine was bubbled through until all the tin was in the stannic condition. On concentrating this solution pale green crystals appeared when the solution cooled. These crystals were filtered off, drained, and dried on a porous plate. They were only slightly deliquescent. On analysis:—

0·4803 grm. gave 0·0566 grm. Ni; Ni = 11·79 per cent.
0·4803 „ „ 0·1452 „ SnO_2; Sn = 23·81 „
0·1160 „ „ 0·2015 „ AgCl; Cl = 42·99 „

$NiSnCl_6.6H_2O$ requires—

Ni	= 11·77
Sn	= 23·84
Cl	= 42·69
H_2O	= 21·70
	100·00

Cobalt Stannichloride, $CoSnCl_6.6H_2O$.—No stannochloride of cobalt was obtained.

For the stannichloride 7·1 grms. of cobalt chloride ($CoCl_2.6H_2O$) and 6·7 grms. of stannous chloride were dissolved in 100 cc. of dilute hydrochloric acid by warming. Chlorine was bubbled through the solution until all the stannous tin was converted into the stannic state. Slow evaporation to small bulk and subsequent cooling produced a crop of small pink crystals which were separated off.

Like the nickel salt these crystals were only slightly deliquescent, and the aqueous solutions did not readily hydrolyse. On analysis:—

1·0035 grm. gave 0·1191 grm. Co Co = 11·83 per cent.
1·0035 „ „ 0·3135 „ SnO_2; Sn = 24·61 „
0·1701 „ „ 0·2913 „ AgCl; Cl = 42·38 „

$CoSnCl_6.6H_2O$ requires—

Co	= 11·82
Sn	= 23·85
Cl	= 42·66
H_2O	= 21·67
	100·00

THE PERCHLORATE METHOD FOR THE DETERMINATION OF THE ALKALI METALS.

By F. A. GOOCH and G. R. BLAKE.

In the work of which an account is here given, the object at the outset was the examination of the perchlorate precipitation of rubidium and cæsium, as proposed by Montemartini and Matucci (*Gaz. Chem.*, 1903, xxxiii. 189), for the estimation of those elements; but the recent paper of Baxter and Kobayashi, which appeared while this work was in progress, upon the perchlorate determination of potassium, suggested the desirability of including that element also within the scope of the investigation. In the work of Baxter and Kobayashi (*Journ. Am. Chem. Soc.*, 1917, xxxix., 249), careful attention i[s] paid to the relations of solubility of potassium perchlorat[e] in the washing media, the use of alcohol containing abou[t] 0·1 per cent of perchloric acid (as first proposed by Wense *Zeit. Anal. Chem.*, 1891, v., 691), and saturated wit[h] potassium perchlorate (as suggested by Davis, an[d] advocated by Thin and Cummings, *Journ. Chem. Soc.* 1915, cvii., 361) is adopted, and further recommendation[s] are made that the washing alcohol be of absolute strengt[h] and of a temperature as near as possible to 0°. Th[e] authors state that there is no danger of the deposition [o]f potassium perchlorate from the saturated alcoholic solu[-]tion owing to upward change of temperature during th[e] manipulation, and make record of the observation that th[e] addition of a large amount of sodium perchlorate failed t[o] induce the precipitation of potassium perchlorate from th[e] solution saturated with the latter salt. It is obvious, how[-]ever, that if a condition of supersaturation in respect t[o] potassium perchlorate were brought about by the additio[n]

of sodium perchlorate to the solution, the contact of the supersaturated solution with potassium perchlorate already precipitated might induce a further precipitation of that salt from the washing liquid; and this is a point of much importance in the application of the perchlorate method to the determination of rubidium and cæsium. We have therefore tested the matter by adding sodium perchlorate to a saturated solution of potassium perchlorate in alcohol (97 per cent), made and used at the working temperature of the laboratory, shaking the solution in contact with a weighed amount of solid potassium perchlorate, filtering and weighing upon asbestos the insoluble precipitate. In the first two experiments solid sodium perchlorate was dissolved in the saturated alcoholic solution of potassium perchlorate to which a weighed amount of solid potassium perchlorate had been added. In the last two experiments the sodium perchlorate was dissolved to a clear solution in the alcohol previously saturated with potassium perchlorate, and to this liquid mixture the weighed amount of solid potassium perchlorate was added. The mixture in each case was thoroughly shaken and filtered upon asbestos in the perforated crucible. The precipitate, transferred by the use of the filtrate and gathered in thin compact layer upon the asbestos felt, was washed with a small amount of alcohol (about 5 cc.) applied in portions successively with intermediate drainings. The results, given in Table I., show that when a saturated solution of potassium perchlorate in alcohol is used as the washing liquid for precipitated potassium perchlorate in presence of sodium perchlorate, there is the possibility that the precipitate may be augmented by potassium perchlorate derived from the washing liquid.

TABLE I.—*Treatment of the Saturated Solution of Potassium Perchlorate in Alcohol.*

$KClO_4$ taken. Grm.	$KClO_4$ found. Grm.	Excess of $KClO_4$ found. Grm.	Volume of saturated alcohol Cc.
0·1025	0·1050	0·0025	50
0·1020	6·1036	0·0016	50
0·1029	0·1048	0·0019	50
0·1012	0·1033	0·0021	50

As regards the solubility of potassium perchlorate in alcohol carrying a small amount of perchloric acid, as recommended by Wense (*loc. cit.*), it is evident that the solvent effect may be modified, without the use of a medium saturated with the salt to be precipitated, by restricting the amount of liquid used in the digestion, transfer, and washing the precipitate. We have therefore tried the expedients (1) of keeping the volume of liquid low, and (2) of again using the first filtrate after the digestion for transferring the precipitate to the filtering crucible, completing the washing of the crystalline precipitate with a very small amount of the washing liquid applied in successive portions. The effects of these procedures, in the perchlorate determination of potassium, rubidium, and cæsium, are shown in the following account of the experimental work.

In all the tests the carefully prepared alkali chlorides were weighed in small beakers, dissolved in water, and treated with pure perchloric acid which distilled without residue. The liquid was evaporated to the fuming point of perchloric acid. For the smaller amounts (0·1 grm.) of material a single evaporation proved to be effective in converting the chlorides to perchlorates. In the case of the larger amounts the residues were redissolved in a little water and then subjected to one or two similar treatments with perchloric acid. The residues were digested with the alcoholic washing liquid (97 per cent alcohol, containing about 0·1 per cent of perchloric acid), transferred to an asbestos filter in the perforated crucible, washed, dried at about 130°, and weighed. In some cases the precipitate was redissolved, and again treated after decantation of the solution before repeating the treatment with perchloric acid and transferring the precipitate to the filter. These details of treatment are indicated.

Table II. contains results of experiments with potassium chloride. Those of section A represent results obtained by keeping the washing liquid within moderate limits. In section B are the results obtained by using the first filtrate instead of the washing liquid to effect the transfer of the precipitate to the filter.

The results and details of similar experiments with pure rubidium and cæsium chlorides are given in Tables III. and IV., and with mixtures of potassium, rubidium, and cæsium chlorides in Table V.

TABLE III.—*The Determination of Rubidium as the Perchlorate.*

RbCl taken. Grm.	$RbClO_4$ found. Grm.	Theory for $RbClO_4$. Grm.	Error. Grm.	$HClO_4$, 70 per cent. Cc.	Filtrate (approx.). Cc.
A.—The transfer made with the washing solution after washing fifteen to twenty minutes. (One evaporation in glass).					
0·1000	0·1527	0·1529	−0·0002	0·1	60
0·1000	0·1528	0·1529	−0·0001	0·1	60
0·1000	0·1529	0·1529	0·0000	0·1	60
(One evaporation; two decantations).					
0·1000	0·1527	0·1529	−0·0002	0·1	20+20
0·1000	0·1531	0·1529	+0·0002	0·1	20+20
(One evaporation in glass).					
0·1000	0·1531	0·1529	+0·0002	5	60
0·1000	0·1530	0·1529	+0·0001	5	60
0·1000	0·1526	0·1529	−0·0003	5	60
B.—The transfer made with the washing liquid without standing to digest. (One evaporation with large amount of perchloric acid).					
0·1000	0·1526	0·1529	−0·0003 (*a*)	5	60
0·1000	0·1525	0·1529	−0·0004 (*a*)	5	60
0·1000	0·1524	0·1529	−0·0005 (*a*)	5	60
0·1000	0·1521	0·1529	−0·0008 (*a*)	5	60
0·1000	0·1508	0·1529	−0·0021 (*a*)	5	60
C.—The transfer effected, after digestion, with the use of the filtrate. (Three evaporations in platinum).					
0·1000	0·1534	0·1529	+0·0004	3×0·1	20+5
0·1000	0·1526	0·1529	−0·0003	3×0·1	20+5

(*a*) These results are low in spite of possible contamination by silica. See Table V., A.

TABLE IV.—*The Determination of Cæsium as the Perchlorate.*

CsCl taken. Grm.	$CsClO_4$ found. Grm.	Theory for $CsClO_4$. Grm.	Error. Grm.	$HClO_4$ (70 per cent). Cc.	Filtrate (approx.) Cc.
A.—The transfer made with the washing solution. (One evaporation in glass).					
0·1000	0·1365	0·1380	−0·0015	0·1	60
0·1000	0·1368	0·1380	−0·0012	0·1	60
0·1000	0·1378	0·1380	−0·0002	0·2	45
0·1000	0·1372	0·1380	−0·0008	0·2	45
0·1000	0·1376	0·1380	−0·0004	0·2	20
B.—The transfer made with the use of the filtrate. (One evaporation in glass).					
0·1000	0·1376	0·1380	−0·0004	0·1	20+5
0·1000	0·1378	0·1380	−0·0002	0·1	20+5
0·1000	0·1378	0·1380	−0·0002	0·1	20+5
0·1000	0·1377	0·1380	−0·0003	0·1	20+5
(Three evaporations in platinum).					
0·1000	0·1379	0·1380	−0·0001	3×0·1	20+5
0·1023	0·1411	0·1412	−0·0001	3×0·1	20+5

TABLE II.—*The Determination of Potassium as the Perchlorate.*

KCl taken Grm.	NaCl taken. Grm.	$KClO_4$ found. Grm.	Theory for $KClO_4$. Grm.	Error. Grm.	$HClO_4$, 70 per cent. Cc.	Filtrate (approx.). Cc.
		A.—The transfer made with the washing solution.				
0·1007 (*a*)	—	0·1862	0·1871	−0·0009	0·1	60
0·1009 (*a*)	—	0·1870	0·1875	−0·0005	0·1	60
0·1014 (*a*)	—	0·1876	0·1884	−0·0008	0·1	60
0·1005 (*a*)	—	0·1862	0·1867	−0·0005	0·1	60
		B.—The transfer effected with the use of the filtrate.				
0·1000 (*b*)	—	0·1866	0·1858	+0·0008	3×0·1	20+5
0·1020 (*b*)	—	0·1894	0·1895	+0·0001	3×0·1	20+5
0·1005 (*c*)	0·1	0·1872	0·1868	+0·0004	0·1	20+5
0·1033 (*d*)	0·1	0·1924	0·1920	+0·0004	0·1	20+5
0·1016 (*d*)	0·1	0·1894	0·1889	+0·0005	0·1	20+5
0·3015 (*e*)	0·1	0·5622	0·5602	+0·0020	3×0·1	20+5
0·3012 (*e*)	0·1	0·5622	0·5596	+0·0026	3×0·1	20+5
0·3021 (*f*)	0·1	0·5615	0·5613	+0·0002	3×0·1	10+10+5
0·3002 (*f*)	0·1	0·5571	0·5578	−0·0007	3×0·1	10+10+5
0·3013 (*f*)	0·5	0·5613	0·5598	+0·0015	3×0·1	10+10+5
0·3008 (*f*)	0·5	0·5603	0·5589	+0·0014	3×0·1	10+10+5

(*a*) One evaporation in glass.
(*b*) Three treatments and evaporations in glass, following solution in each case in the least amount of water.
(*c*) One treatment in platinum.
(*d*) One treatment in quartz.
(*e*) Three treatments and evaporations in platinum without decantation, following solution in each case in the least amount of water.
(*f*) Three treatments and evaporations in platinum; digestion of the residue with 10 cc. of washing solution, decantation, solution, evaporation, digestion, and transfer with 10 cc. of washing liquid.

TABLE V.

KCl taken. Grm.	RbCl taken. Grm.	CsCl taken. Grm.	Perchlorate found. Grm.	Theory for perchlorates. Grm.	Error. Grm.	$HClO_4$, 70 per cent. Cc.	Filtrate. Cc.
		A.—One evaporation in glass; transfer with the use of filtrate.					
0·1004	0·1000	0·1004	0·4633 (*a*)	0·4781	−0·0148 (*a*)	0·3	20+20
0·1011	0·1000	0·1005	0·4605 (*a*)	0·4795	−0·0190 (*a*)	0·3	20+20
0·1014	0·1000	0·0807	0·4562 (*b*)	0·4527	+0·0035 (*b*)	5	20+20
0·1019	0·1000	0·0843	0·4586 (*b*)	0·4558	+0·0072 (*b*)	5	20+20
		B.—Three evaporations with intermediate solution in platinum; transfer by means of the filtrate.					
0·1038	0·1000	0·1025	0·4873 (*c*)	0·4873	0·0000 (*c*)	3×0·4	20+5
0·1010	0·1000	0·1018	0·4817 (*c*)	0·4811	+0·0006 (*c*)	3×0·4	20+5

(*a*) After dissolving in water and again evaporating with 0·3 cc. of the perchloric acid the recovered residues showed *error of +0·0006 grm. and +0·0012 grm. respectively—showing the imperfect conversion of large amounts of* chloride in a single evaporation with a moderate amount of perchloric acid.
(*b*) These residues, obtained by evaporating with a large amount of perchloric acid in glass, contained silica. After dissolving, filtering, and reprecipitating the errors were reduced to +0·0009 *grm.* and +0·0015 grm. respectively.
(*c*) Upon dissolving these residues, again precipitating, and weighing, errors found were −0·0004 grm. and +0·0004 grm. respectively.

The results of the experiments recorded go to show (1) that the use of an alcoholic liquid saturated with the substance to be precipitated is unnecessary to the attainment of good analytical results; (2) that it is practicable to so restrict the volume of the washing liquid (97 per cent alcohol containing 0·1 per cent of perchloric acid) that the solubility of the precipitated perchlorates is insignificant for practical purposes; (3) that a single evaporation with a moderate excess of perchloric acid (0·1 cc. for every 0·1 *grm. of salt) is not sufficient to convert considerable* masses of alkali chlorides (*e.g.*, 0·3 grm.) completely to perchlorate, and that in such a case the residue of the first evaporation with perchloric acid should be dissolved in the least amount of water, another portion of perchloric acid added, and the evaporation repeated; (4) that in separations of the larger amounts of insoluble perchlorates (0·3 grm.) from sodium perchlorate the residue left after digestion of the nearly dry mass of perchlorates in the washing liquid and decantation should be dissolved in a small amount of water, and the process of evaporation and extraction repeated; (5) that in the [illegible] digestion of the residue for fifteen or twenty minutes with the washing liquid before effecting the transfer is advantageous.

It is to be noted that the evaporation of large amount of perchloric acid in glass may result in a considerable action upon the glass, and it has been found that perchloric acid which has stood a long time in glass may yield an appreciable residue on evaporation.—*American Journal of Science*, xliv., Nov., 1917.

Royal Institution.—A General Meeting of the Members of the Royal Institution was held on the 6th inst., Sir James Crichton-Browne, M.D., F.R.S., Treasurer, in the Chair. The following Vice-Presidents were elected:—Henry E. Armstrong, LL.D., F.R.S.; Sir Wm. Phipson Beale, Bart., K.C., M.P.; Sir Charles Nicholson; the Hon. R. C. Parsons, M.A., M.Inst.C.E.; the Right Hon. Lord Rothschild, F.R.S.; the Right Hon. Lord Wrenbury, P.C., M.A.; Sir James Crichton-Browne, M.D., F.R.S., Treasurer; Colonel E. H. Hills, C.M.G., R.E., F.R.S., Secretary. Sir George Stewart Forbes, George H. Heard, and Lieut.-Col. C. S. Myers were elected Members.

SOME SUITABLE MATERIALS FOR PAPER-MAKING.

By JAMES LEIGHTON, F.R.H.S.

THE present is a fitting time to direct our attention to new sources of supply of suitable material for the manufacture of paper. The great scarcity of all kinds of paper is felt, and prices have advanced from 200 per cent to 600 per cent, according to kinds required.

Many of our indigenous and exotic plants are capable of producing a good quality of paper, but we need to give our attention only to those kinds that are of suitable quality and easily obtainable in quantity.

In the early days of the industry, paper was made from rags, worn-out garments, cuttings, and waste from looms. Later, it became necessary to find other sources of supply, of which straw, disintegrated wood, and the Esparto (or Alfa grass) of Spain and North Africa are the chief. England uses very largely the Esparto grass, which grass is not used at all in America, where about 75 per cent of the pulp used is obtained from wood. The finest grades of paper are still made from flax and cotton, but this amounts only to about 5 per cent of the total. Plant fibre when pure is a white semi-opaque substance, insoluble in all ordinary solvents, and chemically known as cellulose, the formula being $C_6H_{10}O_5$; that is, six equivalents of carbon, ten of hydrogen, and five of oxygen are united together to form the substance known by that name. These proportions are constant, although the physical characteristics may differ widely. Before the cellulose can be made available for the manufacture of paper, it must first be freed from its combination with the non-cellulose constituents with which it is united to form the plant structure. Cotton as well as the filiform silky bracts of the involucre of *Typha* are examples of pure cellulose. We are fortunate in having large supplies of suitable material in the form of Tambookie grasses capable of making the larger lines of paper in daily use. These grasses have been thoroughly examined by the Imperial Institute, and pronounced to be about equal to the well known Esparto grass.

I am indebted to Dr. A. Schulz, of Durban, for various samples of wrapping paper made from different species of Tambookie grasses obtained from various parts of South Africa, but all species having the same characteristics. Bertrams, Limited, of Edinburgh, who have prepared these samples, pronounce them "excellent," and state that "There is no doubt that this material will produce a reasonably strong paper without the assistance of any stronger materials."

They state, however, that "It must be kept in mind that pulp made from any grass such as Tambookie cannot produce a strong wrapping paper to compare with paper made from hemp or the like." They state that "the fibres in Tambookie are very similar to those in Esparto, and Esparto will not make what is termed a strong paper, but it does make a paper of a high quality." The samples were all made without the addition of any colouring, and show the material colour of the pulp. I believe one of the grasses submitted to Bertrams was *Andropogon hirtus*, L., a grass common throughout the country and growing to a height of from 2 to 3 feet.

Andropogon nardus, L., var. *marginatus*, Hack, a rigid coarse grass growing in dense tufts to a height of 5 or 6 feet, common on patches adjoining the forest and on flat damp hill-tops and moist places. Stock do not eat this grass, but it is in much demand as a thatch, and if properly used will last twenty years. As its name implies, it is pleasantly scented. The lemon grass of India is a species of *Andropogon*. Mr. Jas. Simpson, of Port Elizabeth, a practical papermaker, has kindly prepared paper from a sample of this grass, which he pronounced to be first of a number of good samples prepared by him. The menu cards used at the last Port Elizabeth Agricultural Show Dinner were made from this grass.

Cyperus textilis (common near rivers and wet localities throughout the country) is capable of producing a very strong paper, and would prove of great value for mixing with grass pulp when an extra strong paper is required.

Another species of *Cyperus*, *C. hexangulare*, is probably not inferior to the last-named species as a pulp-producing plant. This species grows in less moist places and more in the open than the *C. textilis*, but it is usually a close neighbour. Like the former species, 5 or 10 per cent of this fibre will do much to strengthen the grass pulp.

Sansevieria thyrsiflora, a liliaceous plaint fairly common as an underbush throughout the Eastern Province, is capable of producing a very fine paper, but it is of more value as a cordage and will be dealt with under that heading. The Plaintain produces a fine fibre suitable for the production of a strong paper. The plant can be grown in many places where the less hardy Banana would not thrive.

Fleurya peduncularis, a precumbent nettle common in moist places, makes a fine paper, but it is not found in great quantities.

Agave americana has been introduced all over the country, and there are large quantities now ready for use for producing paper-pulp. Mealie cob husks are of increasing value for paper-making, and the centre of the cobs from which the mealies have been separated is used for the manufacture of celluloid and as a material from which a kind of linoleum is prepared.

With so much valuable material at hand it should not be difficult to supply a mill with pulp for the production of wrapping papers and a bleached paper for newspapers.

Some suitable centre should be selected near the source of supply, where pure water is plentiful, and, if sufficient for motive power, it would be desirable, otherwise the mill should be erected where fuel is plentiful at some convenient centre.

In India a superior chemical paper made from local raw material has, owing to its cheapness, ousted the foreign inferior article out of the market. With the abundant supply of excellent material at its disposal South Africa should not stand behind India in this respect, but should retain at least half of the large sum of over £400,000 annually spent in the import of paper into the Union.

The *Andropogon nardus* will produce close on 50 per cent of pulp. Pulp requires the addition of about 10 per cent of extra stuff, clay, size, &c., to make it into paper.

I have dealt with but a few of the species of grasses and other plants which might be utilised for the purpose of paper production, but doubtless there are many other plants that will prove of value for this purpose, especially among the monocotyledons, and with such a plentiful supply of raw material it remains to be seen whether South Africa will utilise its resources and supply an industry which would be beneficial to commerce as well as a valuable asset to the country.—*South African Journal of Science*, xiv., No. 6.

VULCANISATION OF RUBBER BY SELENIUM.

By CHARLES R. BOGGS,
Rubber Laboratory of the Simplex Wire and Cable Company, Boston, Massachusetts.

VULCANISED rubber has been manufactured for some years, but there has really been no essential change from the general methods of vulcanisation as originally specified by the inventors. The two original methods, which are still in use, are the vulcanisation with sulphur by heat and that by sulphur chloride in the cold. Variations in the processes have been introduced and innumerable mixtures made with other materials, but no rubber article of practical importance has been put on the market which has essentially deviated from the two original processes.

There have been made, however, many slight variation in compounding rubber mixtures which have produce

vulcanised rubber products that are characterised by properties which fit them to special work better than any previously known compounds. It was with this idea that we throught rubber vulcanised with selenium might give a product of especial adaptability to some of the many uses of rubber. At the time that we first tried to vulcanise rubber with selenium, 1913, we thought that we were the first, although it is evident that anyone with a knowledge of chemistry would expect selenium to act similarly to sulphur. We have since noticed that Pearson in his book, "Crude Rubber and Compounding Ingredients," mentions two methods, one by heating rubber with equal parts of selenium and the other by dropping liquid selenium into a CS_2 solution of rubber at 300° F. under pressure. It is evident that these methods had nothing to recommend them, and I believe could never have been developed because of the unsatisfactory product.

Selenium is a metal in the same group of the periodic table as oxygen, sulphur, and tellurium, is much more metallic than sulphur, and has a higher melting point (217° C.), sufficiently high to discourage one from attempting to use it as a vulcaniser for rubber which is not capable of withstanding such a temperature. Its atomic weight is 79·2. It occurs in two crystalline and one amorphous form, and forms a complex molecule when cold, Se_8 being very similar to sulphur. A short description of its properties follows:—

Black or grey crystalline.—Octahedral; hexagonal. Sp. gr. 4·80. Insoluble in CS_2. M.-p. 217°.
Red crystalline.—Monoclinic. Sp. gr. 4·46—4·51. Soluble in CS_2. M.p. 175°.
Red amorphous.—Sp. gr. 4·26—4·28. One soluble (and one insoluble) in CS_2. Softens at 102°.

All modifications go over to the black crystalline form when heated at 100° to 150° C. The black crystalline powder can be obtained on the market in small quantities, but it should be procurable in fair amounts if there were a commercial demand for it. Black selenium has the further peculiar property of being an electric conductor under the influence of light although the other forms are insulators. It might, therefore, cause rubber which has been vulcanised with it to show some slightly unusual electrical characteristics.

Our first attempts were made with selenium in the form of black powder used in a standard 30 per cent Para compound in the equivalent proportion that sulphur would be used. By heating at about 150° C. for a couple of hours a partial vulcanisation resulted. The physical tests showed a normal elongation, but a tensile strength of only about 50 per cent of the similar sulphur compound. The point to be noted is that partial vulcanisation was obtained, although the temperature was well below the melting point of Se. Increase in the time did not improve the product. All of these first samples have aged well, and after nearly four years give the same elongation and tensile-strength values of about 70 per cent of the original.

Doubling the amount of selenium and using an organic accelerator, which we were then using with sulphur, did not improve the product but did make the samples go to pieces with age, a normal characteristic of over-vulcanised and under-vulcanised rubber. A peculiar point about this compound was that when it was removed from the press hot it expanded 25 per cent of its volume. Its volume became normal when cold. This high coefficient of expansion indicated lack of vulcanisation.

Using amorphous selenium and an organic accelerator we were able to increase the tensile strength some without sacrificing the elongation. Some other accelerators were tried without much success. The amorphous selenium should go over the metallic form at the temperature used.

The most promising compound we then had was put on wire, and has been tested regularly for the last three years, and the remarkable point is that it has not deteriorated appreciably in that time. This compound was below normal in its tensile strength. The difficulty seems to be that the long heating at the relatively high temperature used to effect vulcanisation caused too great a depolymerisation of the rubber.

By trial we have now found accelerators which enable us to satisfactorily vulcanise rubber with selenium when heated at the ordinary vulcanising temperature of 275° F. (135° C.) for only about twice the time required with sulphur. The product gives the normal tensile strength (1100 to 1200 lbs.) and elongation (2 to 10 in. or 12 in.) of the same compounds with sulphur. It is somewhat soft. This compound shows no deterioration under the short life test of four days' heating in air at 70° C.

Electrical tests have been carried out on wire insulated with this compound, and the insulation resistance and dielectric strength are somewhat low. Special determinations as dielectric loss, &c., have not yet been determined.

Chemical analysis as applied to ordinary sulphur compounds does not apply to these compounds vulcanised with selenium, as the black selenium is practically insoluble in acetone, and consequently the uncombined Se is not separated by extraction with acetone. Also it is only very slightly soluble in $CHCl_3$ and CS_2. The acetone extract contains only the resins from the rubber (provided oils, waxes, &c., are not added). The $CHCl_3$ extract contains some Se and a small amount of unvulcanised rubber as with soft vulcanised rubber when cured with sulphur. A determination of rubber by the tetrabromide method gave 31·7 per cent rubber plus resins, &c., in a compound to which 31·7 per cent rubber had been added. This would indicate that no correction should be made for combined Se, *i.e.*, that the selenium was either not chemically combined, or more likely that it was so weakly combined that it was displaced by Br. It is possible that a complete chemical study of the vulcanisation of rubber with selenium may throw some additional light on the theory of vulcanisation. Also it may help in the study of the nature of the catalytic effect of accelerators as the vulcanisation occurs so far below the melting point of the Se.

The product as we now have it has not yet shown any unusal electrical properties, but the indications are that its deterioration with age is much less than with sulphur compounds. It can be brominised and oxidised, but the natural oxidation seems to have been slowed up. As the deterioration of rubber goods is the one disadvantage of rubber, especially in those lines of work where permanency is desired, it may be that the use of selenium may partially remove this disadvantage.—*Journal of Industrial and Engineering Chemistry*, x., No. 2.

MINISTRY OF RECONSTRUCTION.

Memorandum on Organisation and Work of Interim Industrial Reconstruction Committees.

The Government has already expressed its approval of the proposals put forward in the Whitley Report (see below) that in each industry which has reached a sufficient level of organisation there should be established a Joint Standing Industrial Council consisting of equal numbers of representatives of Associations of Employers and Trade Unions. The Ministry of Labour has been entrusted with the duty of assisting industries in carrying into effect those proposals.

A large number of such Councils is already in process of formation; but in certain industries, owing to various reasons, progress has as yet been slow. In the latter industries, pending the establishment of Industrial Councils, the Ministry of Reconstruction has undertaken, in association with the Board of Trade and the Ministry of Labour, to promote the formation of Interim Industrial Reconstruction Committees consisting of equal numbers of representatives of organisations of Employers and Trade Unions.

What form these organisations should take must depend on the circumstances of each industry. What functions the Committee should assume and what they should leave or delegate to existing organisations or to specially created bodies, are also questions which must be determined by those concerned. But it is not intended that the Interim Industrial Reconstruction Committees, any more than the permanent Industrial Councils, to which it is hoped they will lead, should confine themselves to the consideration of subjects specially referred to them by a Government Department. It is hoped that they will exercise a large initiative in devising means by which the transition from war to peace conditions may be most smoothly effected and the way opened to the rapid restoration of industrial enterprise.

Work of Interim Industrial Reconstruction Committees.

The most urgent questions to which the attention of Interim Industrial Reconstruction Committees should be given are here indicated. It is desired specially to emphasise the importance of those relating to the promotion of industrial organisations and to the questions of employment and supplies of raw materials which are the cardinal factors in industrial reconstruction.

1. *The Promotion of Industrial Organisation.*

Interim Industrial Reconstruction Committees will consider the promotion in the industry of fully representative industrial organisations, both on the side of the employers and of the employed, together with the formation of a Joint Industrial Council in a form appropriate to the industry. Apart from the problems of the transitional period, this organisation should aim at securing understandings, as soon as possible, which will enable both parties (*a*) to co-operate freely in restoring and increasing the productive capacity of the country, (*b*) to provide the basis of representative bodies of a more permanent character for advising and assisting the Government Departments concerned, and (*c*) to assist in providing the peaceful and progressive development to the industry itself.

2. *Demobilisation and Employment.*

(*a*) *Demobilisation.*—The intention of the Government being to demobilise the Forces so far as possible in the order determined by civil requirements, the Interim Industrial Reconstruction Committees should be prepared to furnish the Ministry of Labour who are dealing with these problems with a comprehensive statement showing the prospects of trade and employment in their industry, in order that its claims to priority may be estimated.

The Committees will also be asked to consider :—

(*b*) The arrangements to be made upon demobilisation for re-absorbing into each industry soldiers and war-workers, and the preparation, where necessary, of schemes for the purpose.

(*c*) Questions connected with war pledges affecting the industry.

(*d*) The steps which may be required to facilitate the early restoration of the trade to peace conditions.

(*e*) The problems connected with wages, hours, &c., during the transition period, together with the preparation of schemes whereby possible unemployment may be mitigated during that time.

(*f*) Apprenticeship and training, including the training and conditions of employment of disabled men.

(*g*) The rules and working conditions in connection with the industry and any extensions thereof.

3. *Raw Materials.*

(*a*) The Industries Sub-Committee of the War Priorities Committee have undertaken to consider priority applications in respect of materials required for the manufacture of experimental types, with a view to the post-war development of trade. In giving consideration to such applications the Industries Sub-Committee may require the advice of the Interim Industrial Reconstruction Committees.

(*b*) As regards the position after the war, it seems probable that some allocation of supplies by the Government between the various industries may be necessary for a time in the case of some raw materials, and in order that the total demand may be accurately estimated, each Interim Industrial Reconstruction Committee should at once begin the preparation of a statement showing the quantities of the several raw materials required, together with any advice they may desire to give in the event of some of them being of prior importance to others.

4. *Priority.*

Apart from the provisions of the supplies of raw materials there are, in some industries, certain other supplies, such as those of machinery, which are of the first importance in restoring industrial capacity.

5. *Financial Facilities.*

A Committee has been appointed jointly by the Treasury and the Ministry of Reconstruction "to consider and report whether the normal arrangements for the provision of financial facilities for trade by means of existing banking and other financial institutions will be adequate to meet the needs of British industry during the period immediately following the termination of the war, and, if not, by what emergency arrangements they should be supplemented, regard being had in particular to the special assistance which may be necessary—

(*a*) To facilitate the conversion of works and factories now engaged upon war work to normal production;

(*b*) To meet the exceptional demands for raw materials arising from the depletion of stocks."

It would greatly facilitate the work of this Committee if the Interim Industrial Reconstruction Committees would prepare an authoritative statement of the views of their industries on the special financial problems involved in the conversion from war to peace conditions.

6. *New Industries.*

In the case of the Engineering Trades, the Ministry of Reconstruction has established a Committee to consider the development of new industries. But where an Interim Industrial Reconstruction Committee is in existence, such an inquiry would naturally be undertaken by it or under its auspices on behalf of the industry as a whole. The terms of reference to the Engineering Committee may be quoted as a model:—

"To compile a list of the articles suitable for manufacture by those with engineering trade experience or plant, which were either not made in the United Kingdom before the war, but were imported or were made in the United Kingdom in small or insufficient quantities, and for which there is likely to be a considerable demand after the war, classified as to whether they are capable of being made by—(1) women, (2) men and women, (3) skilled men, and setting out the industries to which such new manufactures would most suitably be attached; and to make recommendations:—

(*a*) On the establishment and development of such industries by the transfer of labour, machines, and otherwise;

(*b*) As to how a transfer could be made and what organisation would be requisite for the purpose, with due regard to securing the co-operation of labour."

With regard to the last words, it is evident that the settlement of working conditions must be undertaken simultaneously, and the Ministry of Reconstruction has for that reason appointed a parallel Committee of Labour Representatives to consider the labour questions involved.

7. *The Disposal of Surplus Government Stores.*

An advisory Board has been established by Order in Council to consider and advise on and "to expedite the preparation of any necessary inventories of property and goods of all descriptions held by Government Departments, and to consider and advise upon the disposal or

alternative form of use of any property or goods which have or may become, during or on the termination of the war, surplus to the requirements of any Department for the purposes of that Department."

The Interim Industrial Reconstruction Committees will be asked to advise the Board on (a) the quantity and kind of goods that can be absorbed by the industry; (b) the steps that should be taken to minimise the dislocation of trade that might be caused by the release in large quantities of marketable articles no longer required for war purposes.

8. *General.*

In addition to the above points, which will become of importance immediately upon the cessation of hostilities, Interim Industrial Reconstruction Committees are urged to invite the co-operation of trade organisations in considering other matters of a like kind which may affect the commercial and manufacturing needs of the trade and industry in the reconstruction period.

Specimen Draft Constitution of an Interim Industrial Reconstruction Committee.

1. The Interim Industrial Reconstruction Committee for the ——— Industry promoted by the Minister of Reconstruction, the President of the Board of Trade, and the Minister of Labour will consist of equal numbers of representatives of Associations of Employers and Trade Unions.

2. The Committee shall elect a Chairman either from amongst its own members or from outside. In cases where no agreement can be come to with regard to a Chairman, the Minister of Reconstruction will, at the request of the Committee, appoint a Chairman.

3. The Committee shall take steps to provide itself with a Secretary and a place of meeting, but during the preliminary stages, may, if desired, meet at the Ministry of Reconstruction, who will provide temporary Secretarial assistance if desired.

4. The functions of the Committee shall be those set out in the Memorandum circulated with the letter of invitation.

5. At least one week's notice shall be given of meetings which shall be called by the Chairman or by the Secretary at his request.

6. The Committee will cease to exist on the formation of a Joint Standing Industrial Council on the lines recommended by the "Whitley" Committee.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, May 2, 1918.

Sir J. J. Thomson, O.M., President, in the Chair.

Papers were read as follows:—

"*Nerve End-cells in the Dental Pulp.*" By J. H. Mummery, D.Sc.

The author has carried further his researches on the distribution of the nerves of the dental pulp.

In a paper published in the *Phil. Trans.* for 1912, he demonstrated that the fibres from the nerve plexus in the pulp beneath the odontoblasts do not terminate at the inner margin of the dentine as described by Huber and others, but that, although they form an open plexus around the odontoblast cells, they are also distributed to the dentinal tubes and enter the dentine in company with the dentinal fibril, but make no connection with it.

Recent preparations with improved methods have demonstrated that the fibres from the deep plexus in the pulp pass to definite nerve end-cells or peripheral nerve end organs which this method of staining has revealed at the inner margin of the odontoblasts.

These end-cells are arranged in groups with slight intervals between them, and are provided with one long unbranched process, the axon of the cell, which passes in a wavy course to the dentine, where it enters the dentinal tube, and with other processes, or dendrons, which divide and branch and are distributed to form the network of fibres around the odontoblast cells.

When stained with gold chloride the end-cells usually have a more or less stellate form, but are of very various sizes and combinations. They can be satisfactorily seen in very thin sections only, and unless the reduction of the gold has been very complete they remain invisible.

"*Nature of Growths in Colloidal Silica Solutions.*" By H. Onslow.

The late Dr. Charlton Bastian claimed to have synthesised certain symmetrical bodies, resembling Torulæ and other minute organisms, from sterilised colloidal solutions which had been exposed for a long period to light. Further, he claimed that such organisms were capable of reproducing themselves.

The author has repeated the experiments, using the special samples of sodium silicate reserved for and recommended by Dr. Bastian and following his directions in every detail. The greatest precautions were taken to avoid accidental contamination.

The results obtained indicate that the method employed yields tubes which are absolutely sterile for all periods up to three years.

PHYSICAL SOCIETY.

Ordinary Meeting, April 26, 1918.

Prof. C. H. Lees, F.R.S., President, in the Chair.

A paper entitled "*Notes on the Pulfrich Refractometer,*" was read by Mr. J. Guild. (Abstract).

The paper deals with points to be observed in the use and design of Pulfrich refractometers. A theoretical investigation of the various errors to which measurements are liable is included.

A paper "*On the Accuracy Attainable with Critical Angle Refractometers,*" was read by Mr. F. Simeon. (Abstract).

The three factors controlling the determination of a refractive index by means of a critical angle refractometer are, so far as the prism system is concerned, (i.) the angle of the prism, (ii.) its refractive index, and (iii.) the angle of emergence of the critical ray from the second prism face. Expressions are obtained for the variation of the required refractive index with each of these factors separately, and curves are given connecting these variations with the angle of emergence from the second prism face for various prism angles.

Discussion.

(The two papers were discussed together).

Mr. Simeon expressed interest in certain of the points mentioned in the first paper. He described the new graticule fitted by Messrs. Hilger. He was surprised that no reference to temperature measurements was made in the paper.

Mr. T. Smith pointed out that the work which formed the basis of the first paper involved the measurement of some 2000 glasses, and was only possible where combined facilities for routine and research work were available on a large scale. He thought Mr. Simeon's curves should have been plotted against refractive indices instead of emergent angles. At present they were misleading. The mathematics could also be simplified.

Mr. Lamplough said he could confirm the advantage of using different liquids with different glasses. He thought Hilger's new graticule very comfortable to use. What was Messrs. Hilger's object in reversing the parts of the instrument?

Mr. Churcher referred to the design of the Abbé

refractometer, and pointed out the necessity for having the lower illuminating prism of dense glass as well as the upper prism.

Mr. GUILD replied to the points raised by the various speakers on his own paper, and expressed his interest in the statements made by Mr. Simeon about some of the features of Messrs. Hilger's new instrument. He criticised Mr. Simeon's paper on the ground that he was not comparing properly comparable quantities in the case of the different prisms, and that his conclusions and also those that would be drawn from his curves were unduly favourable to the 90° prism on this account.

Mr. SIMEON said he had not himself found it misleading to use curves plotted to angles of emergence, and that he had found the curves most useful in many cases. The object in reversing the parts of the instrument in their new model was to bring all the adjustments within reach of the observer's right hand.

Prof. LEES emphasised the importance of close co-operation between the users and manufacturers in order to evolve the most satisfactory instruments for work of high accuracy.

Mr. L. C. MARTIN (communicated remarks) thought the setting of the Pulfrich refractometer must be more sensitive to errors from causes such as irradiation, &c., than the symmetrical setting of the ordinary spectrometer.

Mr. W. FRENCH (communicated remarks on Mr. Simeon's paper) thought it would be useful if the author extended the paper to cover the factors that determine the accuracy in the actual use of the instrument in addition to those governing the first design.

A paper entitled "*Cohesion*" (fourth paper), by Prof. HERBERT CHATLEY, was taken as read. (Abstract).

The paper is the fourth of a series dealing with the subject of cohesion. The aim of the present paper is to consider the value of molecular force as indicated by Van der Waals' gas formula (particularly at the critical state where the liquid and gaseous states merge), and to relate the results to the previous enquiry.

DISCUSSION.

Dr. H. S. ALLEN (communicated):—In this paper Prof. CHATLEY has pointed out a number of interesting relations depending on the equation of Van der Waals. It is more than doubtful whether any attempt to found a theory on purely central attractions and repulsions varying as some power of the distance can prove adequate to explain the facts. It is certain that the law of attraction at molecular distances is not that of the inverse square of the distance. In a lengthy series of papers in the *Philosophical Magazine* (1887, xxiv., 113, 168; 1893, xxxv., 211), Sutherland, whose work has not received adequate recognition, has discussed the law of the inverse fourth power, and has pointed out the relation which it bears to the characteristic equations of Van der Waals and others. A useful summary of work on the subject is given by W. C. McC. Lewis, in his "System of Physical Chemistry" (Longmans, 1916). It may be mentioned that Lewis (*Phil. Mag.*, 1914, xxviii., 104) has examined the connection between the internal pressure or cohesion, π, in the equation—

$$(p+\pi)(v-b) = RT,$$

and the dielectric capacity and permeability of a liquid. He has shown that the Obach Walden relation regarding the proportionality between the internal pressure and the dielectric constant follows from the hypothesis that molecular attraction is electro magnetic, not electrostatic in nature. That cohesion arises from the action of electric or electro magnetic forces may be inferred from optical experiments. The Lorentz-Fitzgerald hypothesis explains the negative result of the Michelson-Morley experiment by a contraction of the material framework of the apparatus in the direction of its motion through the æther. Such a contraction may be predicted from the standpoint of electro-magnetic theory. There is therefore a strong presumption that "the forces of cohesion between the particles, which give a solid its rigidity, are electrical forces" (Eddington, *Nature*, 1918, ci., 15).

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS.

Ordinary Meeting, May 1, 1918.

Dr. S. RIDEAL, President, in the Chair.

CERTIFICATES were read for the first time in favour of Mr. Edward Chapman and Mr. Herbert Savage, A.I.C.

Certificates were read for the second time in favour of Mr. Denys Richard Wood, F.I.C., and Mr. Hubert James Llewllyn Parker.

The following were elected members of the Society:—Messrs. Stanley Dixon, A.I.C.; John Frederick Briggs, A.C.G.I.; Robert Duncan Masson, F.I.C.; and John William Hinchley, A.R.S.M.

The following papers were read:—

"*Factors effecting the Composition of Plant Ashes, with Special Reference to Tobacco.*" By O. D. ROBERTS, F.I.C. (Abstract).

Appreciable amounts of sulphur and chlorine are shown to be lost during the incineration of tobacco by ordinary methods. Processes are given for overcoming inaccuracies in plant ash analyses due to carbon dioxide, and the presence in plants of both organic and inorganic chlorine, sulphur, and phosphorus.

"*Effect of Codeine in Hindering the Precipitation of Morphine by Ammonia from a Solution of its Lime Compound.*" By H. E. ANNETT, B.Sc., F.I.C., and HARDAYAL SINGH, B.Sc. (Abstract).

The authors show that Indian opiums, when assayed by the process recommended in the British Pharmacopœia, give results that are apparently low. They attribute the cause to the high codeine content of these opiums, and suggest a modification of the process by extracting the lime solution of the opium with toluene.

Tables are given contrasting the results obtained by the original and modified methods.

"*Analysis of Cocoa Teas.*" By JULIAN L. BAKER, F.I.C., and H. F. E. HULTON, F.I.C. (Abstract).

"Cocoa shells," sold either under their own or fancy names, are among the various food substitutes at present sold in this country. These shells are separated from the cocoa beans after roasting, and if sold as "shells" and at such a price as is reasonable compared with their wholesale value, there can be no objection to their use, the present wholesale price being about 2d. or 3d. per pound. The authors give a table showing analyses and retail prices of various brands.

"*Estimation of Shell in Cocoa and Cocoa Products.*" By JULIAN L. BAKER, F.I.C., and H. F. E. HULTON, F.I.C. (Abstract).

The authors point out the difficulties which confront chemists in estimating the small quantities of shell in the grades of cocoa mentioned in the Cocoa Order of 1918. Grade A is to contain not more than 2 per cent, and Grade B not more than 5 per cent of shell. It is pointed out that the available methods of estimating shell are not sufficiently accurate to differentiate between Grades A and B.

The methods of estimating shell in cocoa are discussed, and a considerable amount of analytical data are recorded.

Institution of Petroleum Technologists.—At the next meeting, on Tuesday, May 28, at 8 p.m., Mr. J. Wilfred Burford will read a paper on "The Application of Electrical Power to Oilfield Requirements."

CORRESPONDENCE.

DETERMINATION OF MANGANESE IN STEEL.

To the Editor of the Chemical News.

Sir,—Relative to the letter and paragraph in the Chemical News (vol. cxvii., p. 180) by Mr. Thomlinson on the determination of manganese in steel, I have carried out these determinations by the gravimetric and (bismuthate) volumetric methods of determination on the same sample. The results agreed within the limits of error.

It has been my experience that in the asbestos used only Fe and organic matter which may be present will materially affect the volumetric method referred to, and precautions are usually taken to eliminate these from the asbestos used. These are chemical reactions, and I very much doubt that catalytic agents interfere materially with the procedure of the method referred to in your correspondent's letter, or even the likelihood of their presence in asbestos.—I am, &c.,

Joseph Shisko.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Note.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxvi., No. 5, February 4, 1918.

New Method of Preparing Nitriles by Catalysis.—Alphonse Mailhe and F. de Godon.—It is already known that aldehydes react in the cold with ammonia in presence of ether or water, giving products which are generally solid. Thus, ethanal would give the alcohol amine $CH_3.CHOH.NH_2$. The authors have found that in presence of a dehydrating catalyst, such as thoria, ammonia reacts at a suitable temperature on the aldehydic oxygen giving rise to an imine, which, being unstable, loses hydrogen and yields a nitrile,—

$$RC{\lessgtr}^{O}_{H} + NH_3 \rightarrow RCH = NH \rightarrow RCN + H_2.$$

Thus, isoamyl nitrile can be obtained from isoamyl aldehyde. The same reaction can be applied to the aromatic aldehydes.

MISCELLANEOUS.

Potash from Kelp in America.—It is stated that kelp is now being harvested by one concern near San Diego in California in quantity sufficient to supply three times the amount of potash annually imported from Germany before the war. A second plant of equal capacity has been established in the same vicinity, and a smaller plant has also been installed by the Government. Every working day 1500 tons of cut kelp are conveyed by ship to a crushing mill. A sticky gelatinous mass results, containing about 80 per cent of water, and can be pumped through a 6-inch pipe to barges, and thence to digestive tanks of 50,000 capacity each. The material is subsequently put through processes of evaporation.—*South African Journal of Science*, xiv., No. 6.

Fixation of Atmospheric Nitrogen in New Zealand.—The *Journal of the Royal Society of Arts* (lxv., 783) states that at the instance of the National Efficiency Board, New Zealand Government, a project for preparing nitrates from the air by the agency of some of the large falls in the south-western sounds of New Zealand is under consideration. One of the simplest propositions is the utilisation of the Bowen Falls, from which it is estimated energy could be produced at the rate of one-fiftieth of a penny per unit. The chief electrical engineer to the New Zealand Post and Telegraph Department doubts whether there is a more favoured spot in the world than Bowen Falls, and considers that nowhere in Germany, Norway, and Italy can electricity be generated more cheaply.—*South African Journal of Science*, xiv., No. 6.

Literary Notes.—Messrs. Constable and Company will publish almost immediately a new edition, re-written and enlarged, of "Industrial Electrical Measuring Instruments," by Kenelm Edgcumbe, a book which has been out of print for some little time. Among the sections enlarged in this new edition are those dealing with constructional details, power management, induction instruments, current and pressure transformers, and graphic instruments. The new edition contains no fewer than 260 illustrations and diagrams. Messrs. Constable will also publish almost at once "The Production and Treatment of Vegetable Oils," by T. W. Chalmers, in their "Engineer Series." This work, which is fully illustrated, is one which should be in the hands of all those who are interested in this increasingly important subject.

To comply with Regulation 8 (b) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Chemical Laboratory Assistants (Lady) are required at a Gunpowder Factory. Applicants must have had a good education, including training in Elementary Science.—Address, "Superintendent," care of James Willing, Ltd., 125, Strand, London, W.C. 2.

Chemist wanted, or Man accustomed to Chemical production, for shift work in controlled factory. One used to Analysis. Ineligible, discharged soldier preferred. Permanency. State full particulars and salary required.—Address, S. M., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Lady Assistant Chemist (wanted in Rugby district) who has passed either Inter. B.Sc., full B.Sc., or Inter. A.I.C. Examination; Organic and Inorganic Analytical Work. Organic includes large variety of Insulating and Electrical Engineering materials. Opportunity for progressive experience. Several Lady Chemists employed. No person already on Government work will be engaged.—Apply, giving training, copies of testimonials, to your nearest Employment Exchange, quoting No. A 5221.

Metallurgical Chemist for Controlled Works on North-East Coast, with sound knowledge of the Analysis of Copper Alloys. Must have had experience with quick Electrolytic Methods of Analysis. The vacancy offers excellent post-war prospects to a really live man who is not afraid of work. No applicant will be considered under twenty-four years of age.—Write, giving full particulars of experience, stating age and salary required, to the nearest Employment Exchange, mentioning the Chemical News and No. A 5151. No one at present on Government work need apply.

Works Analytical Chemist required. One conversant with Soap Manufacture, Nicotine Extractions, and Agricultural and Horticultural Preparations. State full particulars and salary required.—Address, W. A., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

WOMEN CHEMISTS, with University training or its equivalent, required for ANALYTICAL WORK at salary of £175 per annum, in Government Department in South of England. Previous experience in Technical Analysis not necessary. Annual and sick leave allowed. Other women chemists employed. Salary to be increased to £200 per annum at end of six months if services found to be satisfactory.—Address, C. W., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted for the Laboratory of large Chemical Factory engaged on War work, well-trained and experienced Analysts. Accurate and systematic workers required. Vacancies exist for both Senior and Junior positions, male and female.—Address, "S. 11," Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

THE CHEMICAL NEWS.

Vol. CXVII., No. 3049

NITROGEN AND ITS COMPOUNDS.*

By HORACE FREEMAN, Niagara Falls, Ont.

In the early days of the war when Admiral Von Spee with his squadron of German ships sailed the Pacific Ocean from Alaska to the Falkland Islands and defeated Sir Christopher Craddock at the battle of Coronel, few people actually realised the significance of his movement and the danger in which the Allies were placed by his temporary blockade of the coast of Chile. Chief among those who did, however, was Admiral Sturdee, upon whom some critics placed the blame for Craddock being outclassed in ships and guns, and who himself set sail secretly to meet the victorious Germans and accomplish their complete defeat at the Battle of Falkland Islands.

For in Chile lies the world's one great natural deposit of combined nitrogen, and upon this even yet the Allies are dependent for their supply of explosives and fertilisers. It is an open question whether or not Von Spee hoped successfully to maintain this blockade, but possibly he expected aid from Germany for this purpose. Certainly had he succeeded in capturing the Falkland Islands and maintaining a base of operations there effectively he could have captured or sunk a great portion of the ships carrying nitrate from Chile to Europe.

There is this difference between the Allies and the Central Powers, that whereas the Allies are almost completely dependent upon the natural nitrate of Chile for the production of explosives and many other important substances necessary for our welfare, the Central Powers manufacture theirs from the nitrogen of the atmosphere.

Nitrogen is one of the most abundant elements, for it comprises 75 per cent of the atmosphere which we breathe. It is also one of the most inactive or inert, as chemists say; that is to say, it possesses no disposition to combine readily with the other elements which go to make up the Universe, and it is this inertness which has occupied scientists for nearly a century. The abundance of nitrogen has long been known, but the importance of compounds of nitrogen has only forced itself upon us within the last twenty-five years, and has only become acute since the beginning of the war.

The element nitrogen is the most important of all plant foods. Few plants are able to absorb it directly from the atmosphere; among these few are peas, beans, vetches, and clover. Their action is exceedingly slow, too slow for the present-day demands of agriculture, which cannot afford under modern conditions to have a large percentage of ground devoted to the growth of leguminous plants in order later to plough these in, so to supply food crops of a more important nature with the combined nitrogen necessary for profitable yields. Food crops grown in succession rapidly remove the nitrogen from the soil. This nitrogen gives us our nourishment and to a very large extent gauges the value of food. This is true even of the flesh we consume, for it also obtains its nourishment from the soil.

Stable manure applied to the soil supplies some of the nitrogen in the form of compounds which are available to plants, but this method of fertilisation is at best a very inefficient return to the ground of that which originally came from the ground.

Coal contains nitrogen, and a portion of this is available in the form of ammonium compounds which are obtained from gas-works and coke-ovens, but even this source of suitably combined nitrogen, vast as it is, does not nearly supply the agricultural demand to say nothing of the multitude of other requirements. Moreover, the cost of obtaining this nitrogen from the coal in forms in which it can be sold, whilst not prohibitive, is such that cheaper and more abundant supplies must be obtained to meet the rapidly increasing demands. Fertiliser must be cheap, the cheaper and more abundant it is the better for the cost of living.

Thus it is that the great deposits of nitrate of soda in the soil of Chile have been developed from a production of 900 tons in 1830 to a production of 2,500,000 tons in 1912. The soil in certain rainless districts in Chile contains from 7 to 20 per cent of sodium nitrate, which is supposed to be the result of decay of the vast beds of seaweed carried by the storms of the Pacific on to the land, which has since been upraised by subterrestial action until it lies on a high plateau, safe from the action of the sea. The nitrate is extracted from the soil by the simple method of dissolving it in water. These deposits of Chile are by far the largest in the world, and it is unlikely that any other of a similar nature will be found. They have been exploited by British and German capital, and luckily for us the fight for control in this field was not won by Germany.

Chilean nitrate besides being the great source of fertiliser nitrogen supplies the Allies with by far the major portion of mixed nitrogen which enters into the composition of all military explosives, and without it the Allies would be fighting a very poor defensive and their big guns would be useless. All modern explosives are made with nitric acid, and all the nitric acid used in England and France at the outbreak of war was made from Chilean nitrate, and, in fact, practically all the acid used by them to-day is obtained from the same source, thanks to the Navy.

But many years ago Germany realised that she could not hope to conduct a great war if she were not independent of this raw material for her explosives, and her scientists have received the encouragement of their Government in their endeavours to find means whereby in case of blockade their country would be able to supply its soldiers with food and munitions independently of any outside source. This was part of their preparation for "the day," and we know only too well how successful they have been in this direction.

The nitrogen of the air is their raw material. Scientists of all the great nations have sought for a century the means whereby this great reservoir might be made to yield its life sustaining and life protecting element nitrogen in forms suitable for the purposes mentioned. Before the war the increase in the world's population urgently demanded the solution of this problem, but nowhere was its solution sought so energetically and imperatively as in Germany, whose Empire is not so large as the province of Ontario.

The Chilean deposits cannot last for ever. It is thought that they have reached the maximum development and in fifty or a hundred years will be played out. In any case the cost of producing nitrate from the lower grade deposits is bound to increase, while the world's demand for combined nitrogen is increasing more rapidly than the population as the uses of nitrogen compounds become more and more manifold.

A few figures compiled by Sir William Crookes in 1898 will show how imperative it is that cheap and vast quantities of fertiliser be available for the use of the world's population.

He calculated that there were 515,000,000 bread eaters in that year, and they were increasing at the rate of 6,000,000 a year. Each of these consumed 4·6 bushels of wheat, and the average yield per acre of ground under cultivation was 12·8 bushels.

By 1941 the wheat fields of the world would cover

* An Address read before the Board of Trade of Niagara Falls, Ont. The author spent several years in research work in England upon the production of cyanides from nitrogen, and some years in research work on the same subject in Canada. He is now in-charge of the cyanide department of the American Cyanamid Co.'s works at Niagara Falls, Ont. From the *Canadian Chemical Journal*, ii., No. 4.

292,000,000 acres in order to feed 819,000,000 bread eaters with bread alone. This calculation concerns only wheat consumption; it does not take into account the meat and many other kinds of food which we eat.

Such figures make us wonder how the population of the world five centuries hence will derive its sustenance, but Nature provides a solution for all problems of this kind. In the ordinary course of life man does not seek these solutions until circumstances force the necessity upon him. The nitrogen problem is one of the great exceptions, and to-day we may safely say that the means are at hand, in operation in fact, whereby we may draw upon the vast and limitless stores of nitrogen in the atmosphere for our purposes.

The air over each square mile of the earth's surface contains about 20,000,000 tons of nitrogen in the elemental or uncombined state. The world is using this amount of nitrogen in the form of chemical compounds every fifty years at the present rate of consumption, and up to the last ten years practically none of this has been derived directly from the atmosphere.

Recognition of these facts has been brought to the attention of the countries of Europe and America by the demands of warfare in a manner that has caused each country to seek to provide the means within its own boundaries of securing its foodstuffs and munitions from the storehouse which has no boundaries to blockade.

A veritable army of workers in most branches of science have contributed to the solutions now at hand. The credit does not belong to any one man or country. It is but natural to expect the practical solution to have come from those countries possessing the most congested populations, but the practical solution of necessity only followed the result of pure scientific research conducted wherever research institutions could be found.

Early Attempts to Utilise Atmospheric Nitrogen.

The earliest attempts to utilise the nitrogen of the atmosphere were made with the object of producing prussian blue, which is used chiefly for calico printing and as ordinary laundry blue. The first process was carried out in Paris, and in Newcastle by Bramwell and Company in 1838, and consisted in passing air over a mixture of charcoal and carbonate of potash, in retorts at a high temperature. By this means potassium cyanide was obtained in the product, and this substance was then converted to potassium ferrocyanide by boiling with a compound of iron. The potassium ferrocyanide was then used for the preparation of the blue.

This process has been revived with many improvements up to the present day and always with the same result, positive commercial failure due to the reluctance of the nitrogen to combine with the chemicals used for the purpose, the short life of the plant due to the fluxing action of the alkaline potash on the retorts or furnaces at the temperature above a red heat and the high working cost on a product containing only a very small amount of combined nitrogen.

An attempt was made about 1860 by Marguerite and de Sourdeval to use barium carbonate for the same purpose in place of the potash in order to prolong the life of the apparatus. It proved very much more successful as an absorbent of nitrogen, and a much richer product was obtained. But still the retorts which were externally heated had a very short life, and this method was abandoned. It was revived again by the Scottish Cyanide Company about 1895, which used a mixture of barium carbonate and coal, heated internally by a current of electricity passed through it in the retorts. Nitrogen in the form of producer gas was passed through the heated mass and was absorbed to a considerable extent. The product contained both barium cyanide and barium cyanamide. The cyanide only was extracted and the cyanamide was wasted; consequently the process was not commercially successful.

The results of this work and much other of a similar nature nevertheless proved so encouraging that more workers came into the field. At this period the introduction of the cyanide process of extracting gold and silver created a demand for sodium and potassium cyanide, and this formed the chief encouragement for many workers in France, England, and Germany.

In England, despite the failure of Marguerite and de Sourdeval, the barium process was revived once more, using externally heated retorts made of graphite. Even these costly pieces of apparatus would not stand up under the action of the semi-fused masses, and this process has now been finally abandoned.

The Discovery of Cyanamide.

In Germany the chemists Frank and Caro, still seeking a cheap method of producing cyanide, sought to pass atmospheric nitrogen over various metallic carbides, and their patents describe the use of barium and calcium carbide for this purpose and even of alkali metal carbides. The alkali metal carbides it may be mentioned do not exist, and there are good reasons for believing that they will never be prepared except as chemical curiosities. However, Frank and Caro concentrated upon the use of the chief calcium carbide with the sole object of producing calcium cyanide, a substance which cannot exist in the dry state. Their product they eventually found to be calcium cyanamide. Its value as a solvent for gold and silver is nil, but its value as a fertiliser was soon proven, and Frank and Caro realised that they had solved the great problem—the production of nitrogenous fertiliser from the nitrogen of the atmosphere. They immediately abandoned their object of cyanide production and developed the manufacture and use of calcium cyanamide for a fertiliser, this being by far the larger prize.

The Development of the Arc Process.

The atmosphere contains oxygen mixed with nitrogen, and contemporaneously with the work of Frank and Caro many attempts were made to convert the atmospheric mixture into a chemical compound by bringing these two gases into chemical union. The earliest observation in this connection is that of Cavendish made in 1785, who found that when electric sparks were passed through air an acid was formed. The explanation of this phenomenon was published by Bunsen in Germany in 1857, and it is the same principle which is used to-day on a large manufacturing scale in Norway, as a result of a century of research. It is interesting in this connection to find that the very first industrial attempt to make use of this reaction was made by a Frenchwoman, Madame Lefebre, of Paris, who secured a patent in England in 1859, covering the production of nitric acid from the atmosphere by means of electrical discharges.

This method of utilising the atmosphere was destined to wait upon the results of practical application of hundreds of clever inventions. Its history is the history of electrical development. The first large scale development was erected at Niagara Falls. The means adopted here under the patents of Bradley and Lovejoy consisted in passing the air through millions of electric arcs which rapidly heated it to a high temperature. The cost of power even at Niagara Falls and the wear and tear of the apparatus caused this works to close in 1904.

At this same period the process received the attention of two Norwegian scientists, Birkeland and Eyde, who used the electric arc placed between the poles of a powerful electric magnet. Under these conditions the arc makes a disc of flame and maintains itself in rapid motion, and is greatly enlarged. This gave an advance in the economy of power, but although the original works built by Birkeland and Eyde in Norway have developed to a very large scale the consumption of energy is too great to admit of the process being developed in America. It owes its success in Norway to the easy and cheap electrical development of natural cascades close to the Norwegian tidewaters. At this Norwegian works the air is passed

rapidly through a series of arcs and is rapidly cooled. 35,000 cubic feet of air are used per minute and brought to a temperature of 3000° centigrade, a temperature which, if observed with the naked eye, would soon render one blind. After the gases are cooled they contain nitric oxide as a result of the union of the oxygen and nitrogen, and this is absorbed in lime to form calcium nitrate or is absorbed in water to make nitric acid. A large portion of the output is made to combine with ammonium nitrate, a substance which has wide use in the explosive industry.

The two processes just outlined—the cyanamide process and the arc process—both require considerable amounts of power for their commercial operation, the arc process requiring five times the amount of power that the cyanamide process demands in order to produce the same quantity of fixed nitrogen. Consequently they are both unsuited for countries such as England and Germany, which do not possess the means of producing power in competition with more favoured regions of Europe, such as Norway, France, and Northern Italy. Germany would doubtless like her place in the water as well as in the sun, but, to give her credit, she has sought means for combining nitrogen without the use of large amounts of power, and England, too, under the incentive of war conditions, is now vigorously researching to the same end. Germany has produced the Haber process, which requires only 60 per cent of the power used by the cyanamide process.

The Haber Process.

The Haber process causes nitrogen prepared from the atmosphere to combine with hydrogen gas, forming ammonia from which fertilisers and explosives are prepared. The method is receiving a trial in England, but its commercial success has not been definitely established under conditions of peace. The details of its operation are not widely known, but the nitrogen and hydrogen gases used must be extremely pure and free from oxygen. They are compressed into steel cylinders under a pressure of eighteen hundred pounds to the square inch. These cylinders hold what is called a catalytic agent, in this case uranium, osmium, or metallic finely-divided iron, and they are heated to a low red heat. Under these conditions the gases combine to form ammonia, which as it issues from the cylinders may be condensed to make anhydrous ammonia, or oxidised by admixture with air and passing over heated platinum gauze to form nitric acid, a process described later.

The high pressure used and the nature of the gases require the closest supervision of the Haber process, and as explosions are somewhat frequent the apparatus is fitted with an elaborate system of automatic alarms and bells to give warning of any untoward happening in the compression plant, which is placed out of doors in concrete pits. The capital outlay on the plant is larger than that required or the cyanamide process or the arc process. The sole product of the Haber process is ammonia. To make it available in forms which are demanded by explosives manufacturers the ammonia gas must undergo a process of oxidation known as the "Ostwald process." It is thereby converted to nitric acid.

Nitric acid may be produced from any pure ammonia gas irrespective of its source. Calcium cyanamide is now in successful commercial use as a source of ammonia gas for this oxidation process, so that a great outstanding benefit of the development of the cyanamide industry in America is that this country has the means at hand fully developed for supplying its munition makers with their nitric acid and ammonia nitrate. This without loss of time for experimentation on only partially developed processes.

Of the three processes for fixing atmospheric nitrogen the cyanamide process has received the greatest development, and a number of reasons account for its success. The ease and rapidity with which calcium carbide will absorb nitrogen, the high percentage of nitrogen in the product, and more than all the facility with which cyanamide may be converted into practically all the forms of nitrogenous compounds in common use to-day, and even many others which are not in common use, give this process an advantage and unquestionable stability over the arc and Haber process.

Establishment of the Cyanamide Process in America.

The cyanamide process requires large amounts of cheap electrical energy for its operation, and for this reason it has not been developed in England, which has no water-powers, although the improvements in steam engineering and gas-engine developments might yet allow of its introduction there, especially if some concerted movement should take place for the more direct development of power at the coal-pit or even in the mine itself.

The cyanamide process is the best adapted for the conditions and requirements of North America, and was chosen after exhaustive investigation of the different processes in Europe, in 1907 by Mr. Frank S. Washburn, who went abroad with the object of securing the most effective process in order to make a profitable market for a proposed power development in Alabama. The patent rights were purchased for this purpose in 1907 by the American Cyanamid Company.

The establishment of the first and at present only factory for the fixation of atmospheric nitrogen in America or the British Empire at Niagara Falls, Canada, by this company was due to the failure of negotiations for the development of hydro-electric power in the United States, and to the cheap power offered at that time in Canada. When in 1913 capital was obtained in London for the extension of the industry to Alabama, where it was originally intended to go, similar conditions prevailed, and the Canadian plant was extended by the expenditure here of some millions of dollars. There is at present practically no market in Canada for the products of the plant, which find their way to the United States and England, chiefly at present in the form of materials for munitions of war, but its operation has been of inestimable benefit to Canada, and particularly to the community of Niagara Falls. The factory has been enlarged by additions of capital to a possible capacity of 64,000 tons of cyanamide per annum, and it is a matter of regret for ourselves, as well as for the Company, that owing to the shortage of power the Hydro Commission has reduced the power available for this important manufacture of fertiliser and explosives materials.

Since the commencement of operations in 1909 the American Cyanamide Company has energetically sought the maximum development of the possibilities of cyanamide in many fields, and at this plant a great amount of technical work has been carried on under the direction of Dr. W. S. Landis, and the use of cyanamide has been extended into many arts. The plant is up-to-date in every respect. Its employees are better paid than those of any other similar factory, and their welfare is taken care of by a very effective safety committee, whose endeavours have made conditions of working far better than those in the majority of chemical factories.

(To be continued).

Literary Intelligence.—Miss M. M. Mitchell, of the Regent Street Polytechnic, author of several cookery books, has prepared another under the title of "Cookery under Rations." It contains over 200 war-time recipes adapted to the present restrictions of food, and amongst the special features are economy of fats, fatless puddings, fatless pastries, and other dishes for the reduced fat rations, &c. In addition, the economy of fuel is dealt with fully. Messrs. Longmans, Green, and Co. will publish the book within the next few days at the price of 2s. net.

THE NEUTRAL AMMONIUM SALTS OF ORGANIC ACIDS AND THEIR SUBSTITUTED DERIVATIVES.*

[Seventh Communication].

By LE ROY McMASTER and LETA WRIGHT.

This work is a continuation of the preparation and investigation of the properties of neutral ammonium salts of organic acids and their substituted derivatives. The salts described in this paper were prepared by the same general method as was used in the previous investigations, *i.e.*, by passing dry ammonia into solutions of the acids in anhydrous organic solvents. We have thus prepared and studied the ammonium salts of 1.2.3-methylhydroxybenzoic, 1.3.4-methylhydroxybenzoic, 1.4.3-methylhydroxybenzoic, 1.2.4-dihydroxybenzoic, 1.2.5-dihydroxybenzoic, 1.2.4-dinitrobenzoic, *o*-nitrocinnamic, *m*-nitrocinnamic, *p*-nitrocinnamic, α-naphthoic, β-naphthoic, *m*-nitrobenzenesulphonic, *m*-aminobenzenesulphonic (metanilic), 1.2.4 nitrotoluenesulphonic, 1.4-naphthylaminesulphonic (naphthionic), 1.4-naphtholsulphonic, 1.5-naphtholsulphonic, benzilic, oxanilic, and phenylpropiolic acids. After the salts were precipitated and tested for neutrality they were quickly filtered by suction, washed with anhydrous ether, and allowed to stand for a short time in a vacuum desiccator.

(Note.—For previous papers on this subject see *Am. Chem. Journ.*, 1913, xlix., 84; Chemical News, 1913, cviii., 136; *Am. Chem. Journ.*, 1913, xlix., 294; Chemical News, 1913, cviii., 182, 193; *Journ. Am. Chem. Soc.*, 1914, xxxvi., 742; Chemical News, 1914, cx., 212; *Journ. Am. Chem. Soc.*, 1914, xxxvi., 1916; Chemical News, 1914, cx., 224; *Journ. Am. Chem. Soc.*, 1915, xxxvii., 2181; Chemical News, 1915, cxii., 187; *Journ. Am. Chem. Soc.*, 1916, xxxviii., 1785; Chemical News, 1916, cxiv., 217, 224, 238).

Substituted Benzoic Acids.

Methylhydroxybenzoic Acids.—There are ten acids of the formula $CH_3C_6H_3(OH)CO_2H$ known (*Ber.*, 1883, xvi., 1966), and are sometimes called the cresotinic acids. We have been able to procure from Kahlbaum the 1-methyl-2 hydroxy-3-carboxylic acid, the 1-methyl-3-hydroxy-4-carboxylic acid, and the 1-methyl-4-hydroxy-3-carboxylic acid. All three of them gave neutral ammonium salts.

Ammonium Salt of the 1-Methyl-2-hydroxy Acid.—Hübner worked with some of the salts of this acid, but not with the ammonium salt (*Monatsh.*, 1894, xv., 725). No record can be found of its preparation. A very stable salt is formed when an ether solution of the acid is saturated with dry ammonia. It dries in the form of pink-tinted needles which tend to adhere to each other to form cotton-like masses. The salt is exceedingly soluble in ethyl alcohol and will not precipitate from a mixture made of equal parts of alcohol and ether. It is also soluble in methyl alcohol and acetone, slightly soluble in ethyl acetate, and insoluble in ether, chloroform, and benzene. The aqueous solution of the salt does not hydrolyse. The salt is not hygroscopic and does not lose ammonia when dried at 100°. Moist air causes it to lose ammonia lowly.

Calculated for $CH_3.C_6H_3(OH)CO_2(NH_4)$—N, 8·29 per cent; found—8·31 per cent.

Ammonium Salt of the 1-Methyl-3-hydroxy Acid.—No reference to this salt is made in the literature. A quantitative yield was obtained when it was precipitated from an ether solution of the acid. It formed in beautiful pure white needles which, like those of the preceding salt, formed into lustrous cotton-like masses. When the ammonia was passed into the acid solution an amorphous semi-transparent mass formed at first, which very soon changed to a voluminous precipitate of needles which are not deliquescent. The salt is soluble in methyl and ethyl alcohols and acetone, slightly soluble in ethyl acetate, and insoluble in ether and benzene. It is not quite as stable as the preceding salt, since moist air decomposes it rather readily. Dry air at 50° for one hour has no effect on the salt, while at 100° it decomposes slightly within thirty minutes. Its aqueous solution remains neutral and the salt does not hydrolyse.

Calculated for $CH_3.C_6H_3(OH)CO_2(NH_4)$—N, 8·29 per cent; found—8·27 per cent.

Ammonium Salt of the 1-Methyl-4-hydroxy Acid.—When ammonia was passed into an ether solution of the acid there was first formed an amorphous mass, which soon changed to a white cotton-like mass of needles. This was similar to the action taking place in the preparation of the two preceding salts. We attempted to prepare this salt also in an ethyl acetate solution of the acid, since we had found that the 1.2.3- and 1.3.4-salts were only slightly soluble in that solvent. No yield was obtained as the salt was found to be readily soluble in ethyl acetate. It is also very soluble in water, methyl and ethyl alcohols, and acetic acid, but only slightly soluble in benzene. It is not hygroscopic and its neutral aqueous solution does not hydrolyse.

The salt is a little less stable than its two preceding isomers, but even as that it is quite stable. At ordinary temperatures it does not decompose in dry air, and when heated at 50° for one hour it decomposes but slightly. Moist air at ordinary temperatures decomposes it slowly. When heated to 100° the salt decomposes into ammonia and the acid. The literature makes no mention of this salt so far as we can find.

Calculated for $CH_3.C_6H_3(OH)CO_2(NH_4)$—N, 8·29 per cent; N, 8·30 per cent.

All three of these salts have a faint phenol odour, which is also characteristic of the free acids. It should be noted that all of them precipitate from ether solutions of the acids in the form of needle like crystals. It has been found that a majority of the ammonium salts prepared in ether form as non-crystalline bodies.

Dihydroxybenzoic Acids.

Ammonium 1.2.4-Dihydroxybenzoate.—Since the acid is called resorcylic acid, another name for the salt would be ammonium resorcylate. The acid formed an orange-red solution with ether, from which the salt precipitated as a delicately coloured pink powder. It precipitated immediately and in rather voluminous quantities. This delicately coloured salt shared with the free acid the property of making highly coloured solutions. With water a light brown solution was formed, which, upon the addition of sodium hydroxide solution, changed to a dark rich red-brown colour. Ammonium resorcylate is soluble in both methyl and ethyl alcohols, but is insoluble in ethyl acetate, ether, benzene, and acetone. It decomposes slightly in dry air at 50° after forty minutes, and rapidly gives off ammonia when the temperature has been 100° for half-an-hour. Its solution with water remains neutral for some time. The salt is not hygroscopic.

Calculated for $C_6H_3(OH_2)CO_2(NH_4)$—N, 8·19 per cent; found—8·25 per cent.

Ammonium 1.2.5-Dihydroxybenzoate or Ammonium Gentisate.—The acid formed with ethyl acetate a dark brown solution, from which ammonia precipitated a dark gelatinous pasty mass; but on shaking and on further addition of ammonia, this gelatinous mass was replaced by a light brown amorphous powder. The colour became lighter, and when precipitation was complete the precipitate was almost white. When it was dried and powdered it was a very slightly coloured substance, but after standing for five months the colour was somewhat darker, probably on account of slight decomposition.

* From the *Journal of the American Chemical Society*, No. 4.

The salt forms a neutral solution with water, and is soluble in acetic acid and methyl alcohol, slightly soluble in ethyl alcohol, but insoluble in ether, ethyl acetate, benzene, and chloroform. Acetone very slightly dissolves it. It does not lose ammonia on exposure to dry air at 50°, and even at 100° there is but very little loss after some length of time. The salt is not deliquescent.

Calculated for $C_6H_3(OH)_2CO_2(NH_4)$—N, 8·19 per cent; found—8·19 per cent.

A Dinitrobenzoic Acid.

Ammonium 1.2.4-Dinitrobenzoate.—The ammonium 1.3.5-dinitrobenzoate has been prepared in the laboratory of Washington University in ether solution, and found to be a white amorphous powder, having a slight yellowish tinge (*Journ. Am. Chem. Soc.*, 1915, xxxviii., 2187). We have also prepared the 1.2.4-salt in ether. When the ammonia was passed into an ether solution of the acid a transparent yellowish gelatinous mass was first formed. This soon changed to a yellowish white flocculent precipitate and then to an amorphous powder. After drying the salt was found to have the same colour as the 1.3.5-body. It is not as stable in the air as the latter salt, for it gives off ammonia very slowly in dry air and rapidly in moist air. The temperature of the dry air does not seem to affect the rate of decomposition of the salt. The 1.3.5-salt is stable in dry air, and loses its ammonia only very slowly in moist air. Neither salt is deliquescent. The aqueous solution of the 1.3.5-salt does not hydrolyse even on standing for several days, while that of the 1.2.4-salt is neutral at first but becomes acid after several hours. A peculiar difference between the two salts is to be observed in their solubilities. The 1.3.5-salt is soluble in all the ordinary organic solvents except ether, though not very readily in acetone; the 1.2.4-salt is practically insoluble in all the organic solvents except methyl alcohol.

In determining the ammonium nitrogen high results were always obtained so we made determinations of the total nitrogen.

Calculated for $C_6H_3(NO_2)_2CO_2(NH_4)$—Total N, 18·35 per cent; found—18·32 per cent.

The Nitrocinnamic Acids.

Ammonium o-Nitrocinnamate.—The free acid was found to be insoluble in all the usual organic solvents except acetone, in which it is very slightly soluble. Moreover, the ammonium salt is very soluble in most of the solvents, except ethyl acetate and benzene in which it is insoluble. Acetone dissolves the salt but slightly.

When ammonia was passed into a suspension of the acid in ethyl alcohol, a precipitate formed which went into solution at once. It could not be reprecipitated by any reagent obtainable since its solubility in ethyl alcohol is so great. When a suspension of the acid in ether was saturated with ammonia a yellow amorphous precipitate, lighter in colour than the free acid, which has a rich yellow colour, was formed. Tests for neutrality and analysis proved this precipitate to be the neutral ammonium salt. The salt is not deliquescent and its aqueous solution does not hydrolyse. In dry air the salt does not lose ammonia, but does so in moist air.

Calculated for $C_8H_6(NO_2)CO_2(NH_4)$—Ammonium N, 6·67 per cent; found—6·62 per cent.
Calculated for $C_9H_{10}N_2O_4$—Total N, 13·33 per cent; found—13·31 per cent.

Ammonium m-Nitrocinnamate.—The free acid is insoluble in the organic solvents, except in ethyl acetate. When an ethyl acetate solution of the acid was saturated with ammonia a white curdy mass formed, which changed almost at once to a very fine non-crystalline substance. It was very difficult to dry this precipitate. It was not possible to drain off the solvent, even with strong suction; so the pasty mass was placed for about an hour in a vacuum desiccator. It was then ground to a fine chalky powder, which loses its ammonia very slowly in a moist atmosphere. The salt is not hygroscopic, and its aqueous solution remains neutral for several hours. The salt was found to be a rather difficultly soluble compound. It is most soluble in acetic acid, and only sparingly so in water, methyl alcohol, and acetone. It is insoluble in ethyl alcohol, ether, and benzene.

The salt decomposes very slowly in hot dry air. At 50° for thirty minutes the decomposition is slow, but at 100° for fifteen minutes ammonia is rapidly given off. Analysis of the salt prepared in ethyl acetate proved it to be the neutral body.

Calculated for $C_8H_6(NO_2)CO_2(NH_4)$—Total N, 13·33 per cent; found—13·34 per cent.

Ammonium p-Nitrocinnamate.—As in the two preceding cases difficulty was encountered in getting the acid into solution. The acid was so very slightly soluble in all the organic solvents that we tried a suspension of it in ethyl alcohol; but, as was the case with the o-salt, this ammonium salt was so soluble in the alcohol that it would not precipitate nor could we precipitate it by adding large amounts of other solvents to the alcohol solution. When a suspension of the acid in ether was tried we obtained a fine yellow powder of the neutral ammonium salt. This salt was soluble in water with difficulty, readily soluble in methyl alcohol, ethyl acetate, and ethyl alcohol, slightly soluble in acetone, but insoluble in ether, chloroform, and benzene. It decomposed at 50°. The salt is not hygroscopic and its aqueous solution hydrolyses very slowly.

Calculated for $C_8H_6(NO_2)CO_2(NH_4)$—Total N, 13·33 per cent; found—13·32 per cent.

Most of the neutral ammonium salts so far prepared have been found to be readily soluble in water, but these three nitro-salts were unusually difficult to dissolve in water. Ammonium cinnamate (*Am. Chem. Journ.*, 1913, xlix., 300), previously prepared, was found to be much more soluble than these three nitro-derivatives. However, the ammonium nitrocinnamates resemble the ammonium cinnamate in many respects. When ammonia is conducted into an ether solution of cinnamic acid a gelatinous precipitate is first obtained which later changes to an amorphous form. This same phenomenon occurs in the formation of the m-nitrocinnamate in ethyl acetate but not in the formation of the o- and p-salts in ether. We could find no record of any of these salts having been previously prepared even in aqueous solution.

The Naphthoic Acids.

Ammonium α-Naphthoate.—The barium, calcium, and silver salts of α-naphthoic acid have been prepared by Hoffman (*Ber.*, 1868, i., 39), but no reference to the ammonium salt can be found. The acid is not soluble in ether, but is very soluble in hot ethyl alcohol. However, the ammonium salt is so very soluble in alcohol that it is impossible to precipitate it in this medium even in the presence of a large amount of ether. It was therefore necessary to pass the ammonia into a suspension of the acid in ether, whereupon the ammonium salt quickly formed as a fine white powder. The aqueous solution is neutral and does not hydrolyse for a number of hours. The salt is not hygroscopic and does not give off ammonia in dry air at room temperature. Moist air decomposes the salt slowly. When heated to 50° in dry air decomposition is perceptible after forty minutes. After ten minutes at 100° it is rapidly broken up, giving off ammonia freely.

The salt is very soluble in methyl and ethyl alcohols, moderately soluble in acetone and acetic acid, and insoluble in ether, chloroform, ethyl acetate, and benzene.

Calculated for $C_{10}H_7CO_2(NH_4)$—N, 7·41 per cent; found—7·40 per cent.

Ammonium β-Naphthoate.—A number of the salts of β-naphthoic acid have been made and studied, but there

a no record of the neutral ammonium salt (Veith, *Ann.*, 1876, clxxx., 305; Metz and Mühlhäuser, *Zeit. Chem.*, 1869, v., 70). The acid is readily soluble in both ether and ethyl alcohol, and the ammonium salt can be prepared in either solvent. When prepared in ether it forms as a pure white amorphous powder. Its aqueous solution does not hydrolyse. The salt dries quickly, is not hygroscopic, and does not give off ammonia in dry air at ordinary temperatures. In moist air ammonia is given off. At 50° in dry air for thirty minutes the salt decomposes, and at 100° marked decomposition takes place within fifteen minutes.

The salt is insoluble in ethyl acetate, chloroform, acetone, ether, and benzene, and only slightly soluble in ethyl alcohol. Except for certain differences in solubility the properties of this salt closely resemble those of the a-salt.

Calculated for $C_{10}H_7CO_2(NH_4)$—N, 7·41 per cent; found—7·39 per cent.

(To be continued).

THE PIGMENTS OF THE TOMB OF PERNEB.*

By MAXIMILIAN TOCH.

In 1913 Mr. Edward S. Harkness presented to the Metropolitan Museum of Art of New York City, the Tomb of Perneb, which originally stood in the cemetery of the ancient Memphis. Mr. Harkness acquired this tomb from the Egyptian Government, and Dr. Albert M. Lythgoe removed the tomb from Sakkara and re-erected it in the main hall of the Metropolitan Museum of Art.

The tomb was built approximately 2650 B.C., and in it was buried an Egyptian Dignitary named Perneb, who held high office under the king at Memphis. The tomb contained many figures in relief, particularly the side wall in the main chamber, on which the carvings are very profuse. The figures are all coloured with various pigments. (It is a great pleasure for me to acknowledge the assistance that I have received from Dr. Albert M. Lythgoe, through whose courtesy I was given the pieces of limestone and the adherent pigments which were taken from the Tomb of Perneb).

The pigments used on the Tomb of Perneb are red, yellow, blue, green, grey, and black. There is a popular belief that the red used by the Egyptians was red ochre. This is an error, as ochre is yellow naturally, and only turns red when it is burned or calcined. Ochres all normally contain between 10 and 20 per cent of oxide of iron, whereas the reds of the Egyptians contain more than 50 per cent of oxide of iron, and from their very colour it is certain that the red of the ancients was hematite. This is never a very bright red, but is always one which we associate with brick colour.

Yellow.—All the yellows used were the native ochre, which is clay stained with iron rust.

Blue.—The Egyptian blues are very beautiful, and range from a light sky-blue to a dark ultramarine. An examination with a microscope of the dark Egyptian blue shows it to be powdered glass or porcelain. This material has been known as "frith," and has of itself no hiding or obscuring power, nor does it seem to have been put on with a binder. This powdered glass has been rubbed into the surface and allowed to set with the Nile clay or the Nile mud, which, on account of its slightly alkaline nature, is cementitious of itself, and has both setting and binding power. The appearance of this blue glass, which in modern times is called "smalt," appears blue just the same as snowflakes appear white, because the light is broken up on its crystalline structure, yet a single snowflake is as transparent as pure glass.

Greenish blue is azurite, a hydrated carbonate of copper.

Green is malachite, azurite, and clay.

Black is carbon black composed of charred wood or burnt wood or charred bones.

Grey is limestone mixed with charcoal or carbon.

Mr. Lythgoe found two paint pots which had evidently been thrown out by the workmen, and an examination of these shows the pigment to be hematite mixed with limestone and clay.

It is remarkable that in all investigations of historic materials many of the tools and implements used have been either forgotten or in many cases not found. I have, in times gone by, paid a great deal of attention to the pigments used by the old masters, beginning with the primitive painters of Italy and going through the history of the Flemish materials down to the English masters, and while I have had abundant matter I have had hardly any historic data concerning the implements used, such as brushes and palette knives. There are practically no brushes left to show us how the wonderful technique of the older painters has been carried out. The same may be said of the musical instruments. The bows used by the early violinists of Italy are not well known, and their history, method of manufacture, and composition are very largely shrouded in mystery.

There is a brush in the Metropolitan Museum of Art, from one of the excavations of the palace of Amenhotep III. at Thebes, that dates from the XVIIIth dynasty. This brush is similar in size and shape to a medium-sized sash tool used by the house painters of the present day. The bristles are not air, but evidently of a vegetable stalk similar to bamboo, which has been beaten until the longitudinal fibres have separated. It is bound around with a twine of fibre a good deal like hemp, just the same as a modern round paint brush is bound either with wire or cord.

There has been little or no work done on Egyptian pigments, with the exception of the chapter by Dr. Russell, called "Egyptian Colours," in the book "Medium" by Flinders Petrie, compiled in 1892. Dr. Russell was in error, however, when he stated that the splendid rich blue was a silicate of copper, for the samples that were submitted to me proved to be cobalt, and upon investigation I found that A. W. Hoffman demonstrated that the blue frits of the time of Rameses III. were painted with cobalt.

Nearly everyone has made the popular error of assuming that the Egyptians used the white of egg as a binder for their pigments. I cannot find any trace of any albuminous binder in the pigments submitted to me, but they do show some evidence of the use of glue or gelatin. It is well known that the Egyptians manufactured very excellent grades of glue either by boiling parchment or bones and hides of animals. They were excellent cabinet makers, and used glue very largely in joining pieces of wood. In the great museum at Cairo there are to-day many samples of furniture glued together with Egyptian glue which are still in excellent condition. It is, however, more than likely that little or no binder was used when the pigments were applied on the various tombs, even to those built about 1500 years later, like the Temple of Karnak. We all know that the climate of Egypt is exceedingly dry, and therefore no rain can wash off or disintegrate a cold water paint made by means of pigment and glue. The Nile clay and Nile mud largely used in building are slightly alkaline and in many respects similar to the adobe mud in New Mexico and Arizona. This mud contains a small percentage of free lime, and any earthy substance which contains free lime will in time act like a weak cement and become firmly bound. It is therefore my opinion that many of the decorations made by the Egyptians were made without any binder other than the lime naturally found in the soil, and in a few cases glue was used. I also judge, from the nature of the implements used, that the pigments were rubbed into the surface and they in time became part of the surface.

I do not refer to the splendid decorative work in the

* Paper presented at the meeting of the New York Section of the Society of Chemical Industry, October 19, 1917.

wooden sarcophagi when I say little or no binder was used, for in these coffins and on the outside of the linen wrappings there are some really wonderful decorative paintings in which binders were used. The portraits outside of the mummy wrappings in the second century were done with wax and resins and are excellent works of art, although these paintings have nothing to do with the pigments of the Tomb of Perneb.—*Journal of Industrial and Engineering Chemistry*, x., No. 2.

THE MEXICAN PETROLEUM INDUSTRY.*

More than Fifty-five Million Barrels of Petroleum produced in 1917.

THE Technical Commission of the Department of Petroleum under the Secretary of Industry and Commerce has collected the most recent statistics regarding the production of petroleum in the Republic, and these are of great interest.

During the year 1917 a total of 79 wells were bored in the oil regions of Tamaulipas, San Luis Potosi, Panuco, Topila, Ozualama, Tuxpam, and Ichuatlan, of which 43 are producing. The potential production of these wells is 235,250 barrels daily.

With the opening of these new wells the total in the entire Republic reached 919, of which 329 are productive, 362 unproductive, 141 are in process of sinking, and 77 have been localised.

The potential production of these wells is 1,337,012 barrels daily. In 1901 Mexico produced 10,345 barrels of crude oil annually. In 1910 the production had risen to 3,634,080 barrels, while in 1917 the total production was the enormous quantity of 55,292,770 barrels.

The Tuxpam region leads in the amount produced, the total for the year having been 34,500,000 barrels. Tampico produced 20,500,000 barrels, and Minititlan yielded 23,500,000 barrels.

The companies established in Mexico which produced the largest amount of petroleum during the past year were the Huasteca Petroleum Company, which extracted from its wells more than 16,000,000 of barrels, and the Aguila Company, which produced nearly a like amount.

During the year 1917 the exportations of oil reached 6,500,000 metric tons of petroleum, while the value of the crude and refined products amounted to over 53,000,000 dols. Mexican gold, a notable increase over the figures for 1916.

Oil Wells now being Drilled.

The confidence of foreign petroleum operators in the stability of conditions in the Tampico oil fields is evidenced by the fact that the sinking of new wells continues with regularity. The Trans-continental company is sinking four, one of them now being down 1450 feet. The Mexican Gulf Company has one well down 960 feet and another 1000 feet. The East Coast Company has a well down 1500 feet, while the Huasteca Company has one down 1700 feet in addition to the many that have been completed. The Aguila Company has also begun drilling a new well. The International Company has a new well that makes a promising showing, while the East Coast Company has one that is down 1688 feet and is now filled with oil, presaging a good flow within a short distance.

Experts employed in the Department of Biological Studies have reported that after careful investigation of the lands reclaimed by the drainage of Lake Texcoco, in the vicinity of Mexico City, there have been rendered available some thirty millions of tons of mineral salts, including common salt, caustic soda, bicarbonate of soda, &c., for all of which there is a large demand in the Republic in various industries.

The Department of Industry and Commerce has given notice to the national mining agents in all portions of the Republic to permit the denouncement of deposits of graphite, which had been forbidden by a decree of 1912. It is expected that activity will result in the development of this much needed mineral, which is found in various localities in abundance.

Commodious port works are projected at the Island of Lobos, off the Tampico coast, which have for their object the accommodation of the petroleum carrying vessels which ply from that section with great regularity and frequency. It is expected that the Port of Lobos will become one of the most important in the Republic, and all the traffic of this kind will be concentrated there.

A concession has been granted by the Secretary of Industry and Commerce for the exploitation of a deposit of gold, uranium, and radium at Guadalupe, in the mountains of the State of Chihuahua. All the machinery necessary for thorough and extensive operation will be introduced. The Government will receive 5 per cent of the gross output in return for the permission granted. This is the only deposit of these minerals so far discovered in the Republic.

Investigations made under instruction from the Department of Fomento have disclosed the presence in Sonora of extensive deposits of sulphate of molybdenum and also of tungsten, which are of great value in the manufacture of steel as also of incandescent lamp films. These deposits, it is announced, will be developed upon an extensive scale.

Powerful Wireless Station near Tampico.

A new wireless station has been established on the Island of Lobos, off the coast of Tampico, largely for the purpose of affording the various petroleum companies facilities for communicating with their vessels while great distances at sea. This station is provided with some of the most powerful apparatus, and will be able to communicate with the wireless stations at Mexico City, Tuxpan, Tampico, Vera Cruz, Progreso, Frontera, Mazatlan, Santa Rosalia, La Paz, Queretaro, Monterrey, Saltillo, Torreon, and by way of Havana with various stations in the United States. It is expected to prove of great value in advancing the commercial interests of the Republic.

* Bulletin Service of the Mexican News Bureau.

MINISTRY OF MUNITIONS.

AMMONIA AND AMMONIACAL PRODUCTS.

THE Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm Regulations, and all other powers enabling him, hereby orders as follows:—

1. No person shall as on and from the first day of June, 1918, until further notice, produce or manufacture any ammonia or ammoniacal product, except under a license issued by or under the authority of the Minister of Munitions, and in accordance with the terms and conditions of such license as to the quantities to be manufactured or otherwise. Provided that no license shall be required to manufacture:—

(a) Crude Ammoniacal Liquor or Sulphate of Ammonia in any quantities.

(b) Any other ammoniacal product, in quantities not exceeding half a ton, during any one calendar month.

2. No person shall as on and from the first day of June, 1918, until further notice supply any ammonia or ammoniacal product (other than crude ammoniacal liquor or sulphate of ammonia) to any person, except under and in accordance with the terms and conditions of a license issued by or under the authority of the Minister of Munitions pursuant to this Order. Provided that no license shall be required to supply not more than 56 lbs. of anhydrous ammonia, or 1 cwt. of ammoniacal liquor or

any ammoniacal product to any person during any one calendar month.

3. All persons engaged in producing or manufacturing ammonia, or any ammoniacal product, or in any manufacture, trade, or business in which any ammonia or ammoniacal product is used, shall carry out and comply with all instructions and directions which may be issued or given by or on behalf of the Minister of Munitions with a view to avoiding loss or waste of ammonia.

4. All persons engaged in producing, manufacturing, selling, distributing, or storing ammonia, or ammoniacal products, or in any manufacture, trade, or business in which any of the same are used, shall make such returns with regard to their businesses (including returns relating to losses or waste of ammonia), and shall verify the same in such manner (including production of their books to any accredited representatives of the Minister of Munitions) as may from time to time be required by or under the authority of the Ministry of Munitions.

5. For the purposes of this Order the following expressions shall have the following meanings:—

"Ammonia" shall mean and include anhydrous ammonia and ammonia in aqueous solution.

"Ammoniacal Products" shall mean and include all compounds of Ammonia and mixtures or preparations containing Ammonia.

"Crude Ammoniacal Liquor" shall mean an aqueous solution of Ammonia containing not more than 5 per cent of Ammonia.

6. Nothing contained in this Order shall affect or exempt any person from compliance with any of the provisions of the Fertiliser Prices Order, 1918, relating to sales or deliveries of sulphate of ammonia.

7. This Order may be cited as the Ammonia Control Order, 1918.

8. All applications in reference to this Order (including applications for licenses) should be addressed to the Ministry of Munitions, Department of Explosives Supply, Storey's Gate, Westminster, S.W. 1, and marked "Fertiliser Section."

(NOTE.—*Under Clause 9 of the Fertiliser Prices Order, 1918, licenses are required for certain sales and deliveries of sulphate of ammonia, and in particular for all sales of sulphate of ammonia for use in the manufacture of munitions of war or for other industrial purposes*).

May 17, 1918.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, May 9, 1918.

Sir J. J. THOMSON, O.M., President, in the Chair.

PAPERS were read as follows:—

"*Theory of Attraction when the Force varies as any Power of the Distance.*" By Major P. A. MACMAHON, F.R.S., and H. B. C. DARLING.

"*Electromagnet Integrals.*" By Sir GEORGE GREENHILL, F.R.S.

Starting with Maxwell's M, mutual inductance of two coaxial circular currents, a straightforward integration will lead to the analytical expressions arising in the theory of the Ampère-balance current weigher, described in *Phil. Trans.*, 1907, by Ayrton-Mather-Smith, and the complicated dissections are not necessary, employed by Viriamu Jones, Minchin, and other writers.

The elliptic integrals which occur are then reduced to a simple standard form, capable of use with Legendre's tables of the elliptic function, and the quadric transformation is explained geometrically, required to reconcile the conflicting notation of previous treatment.

A re-drawing is submitted of Maxwell's figure XVIII. of the curves of constant M, employing the co-ordinates of the confocal conics on Weir's chart. The same co-ordinates are applied to a state of uniplanar liquid motion, where they appear appropriate, as well as to Euler's problem of the orbit under two centres of force.

"*Intensity Relations in the Spectrum of Helium.*" By T. R. MERTON, D.Sc., and J. W. NICHOLSON, F.R.S.

The paper contains the results of an experimental investigation of the variations in distribution of intensity among the lines of the helium spectrum under various conditions of excitation. The intensities have been examined quantitatively, according to the method described in previous memoirs, at various assigned positions in the cathode dark space and beyond, so that the variations can be determined as definite functions of cathode distance.

It is found that the relative intensities of lines in the diffuse series of helium and parhelium remain essentially the same at all distances, but that striking variations occur in other types of series. The results are discussed (1) from the point of view of selective transfer of energy in any one series; (2) in relation to type of series—diffuse, sharp, or principal; and (3) in relation to the relative behaviour of the doublet and single line spectra.

The spectra of mixed gases—hydrogen and helium—have also been studied in the same way, and it has become apparent that the phenomena presented by the presence of a spectroscopic trace of one of the gases are essentially different in character from those presented when the gases are mixed in comparable amounts. The low pressure spectrum of helium has been investigated quantitatively, and the results have been discussed with special reference to the reproduction in the laboratory of the abnormal intensity relations found in the spectra of the nebulæ. It is shown that the nebular spectrum of helium would be obtained very closely by a combination of the conditions belonging to the condensed discharge and to the low pressure spectrum.

"*Outline of a Theory of Magnetic Storms.*" By S. CHAPMAN, D.Sc.

The average characteristics of magnetic storms are separated into two parts, depending respectively on time measured from the commencement of the storm and upon local time. In the former the horizontal force is the element chiefly affected, a brief initial increase being followed by a much larger decrease, extending over several hours. Afterwards, during a period of days, the force slowly returns to its normal value. The local time changes, after the ordinary diurnal magnetic variations have been removed, are approximately simple sine or cosine waves in all three elements. Their mutual relations in phase, and the dependence of their amplitudes upon latitude, are determined for twelve observatories, from the mean of forty storms. The two sets of variations are interpreted in terms of electric current systems circulating in the upper atmosphere (with corresponding earth currents). These, again, are referred to the inductive action of a system of atmospheric motions. These motions are primarily vertical, though the unequal distribution of vertical velocity introduces horizontal movements also. The atmospheric motions are explained as the result of the precipitation of electric particles from the sun into the earth's atmosphere. A depression of the absorbing layer (which becomes ionised) is first produced. This is succeeded by a general upward expansion, due to the mutual repulsion of the particles (which are mainly of one sign of charge) which are entangled in the layer. The stratum in which these actions occur is considered to be above that in which the ordinary diurnal magnetic variations are produced, and the ionisation in the latter layer is attributed to the action of ultra-violet light from the sun.

SOCIETY OF GLASS TECHNOLOGY.

Ordinary Meeting, May 15, 1918.

Mr. W. F. J. Wood, B.Sc., F.I.C., President, in the Chair.

After the usual formal business the President opened a discussion on "*The Glass Industry after the War.*" He stated that the glass industry could be divided into eight main sections:—(1) Table and decorative, (2) plate and sheet, (3) optical, (4) chemical and scientific, (5) electric lamp bulb, (6) pressed, (7) common bottles and jars, (8) flint bottles and jars. He then went on to advocate the formation of a trade council in each section which should organise its own particular section, and a federation of these trade councils, consisting of 44 members. Each section should elect 4 members, 2 being manufacturers and 2 workmen. This would give 32 members. The remaining 12 should be made up of 4 scientific representatives, 6 Government representatives, and 2 representatives of finance. Such a council would have great possibilities in front of it, representing as it would all shades of opinion in the industry. It was necessary that each section should take steps to organise as quickly as possible. Workmen should be encouraged, and the best machines available should be introduced, so that the country could make all its own glass instead of some 20 per cent as in pre-war days. In the opinion of the speaker it was obvious that some kind of Government assistance must be given to the glass industry. A strong case for protection in some branches and prohibition in others could be made out. Without this there would be a deluge of foreign glass after the war, just when we should be requiring rest, when our furnaces and shops ought to be undergoing repairs, and when time was required for the training of workmen. It was to be hoped that the optical munitions and glassware branch of the Ministry of Munitions would be kept in being after the war, as there is no measure of the indebtedness of the industry to this department. There is evidence abroad that the German glass firms are consolidating under Government control, and it is necessary that we in the country should be prepared to fight them.

Mr. J. Connolly followed with an appeal to the whole industry, both masters and men, to pull together. Owing to unfair foreign competition the glass trade in this country in certain branches was less than 50 per cent of what it was fifty years ago. The industry demanded from the Government a square deal, and then it could defy foreign competition.

What we required was a dump-proof Empire where a fair chance would be given to home production. Given this fair chance there was no fear that we could not only equal but surpass German and Austrian production.

Sir Frank Heath, K.C.B., of the Department of Scientific and Industrial Research, spoke of the absolute necessity of bringing science to bear on output, both from point of view of quantity and efficiency. The Government fully recognised the importance of industrial research, and was prepared to assist it in a wide sense through trade and industrial organisations. The conditions of grants to industries for research were not likely to be onerous or difficult, and there would be no meticulous or tyrannical interference from headquarters.

Mr. D. Baird briefly outlined what had been done to capture the chemical ware trade from Germany, and spoke of the work still to do. It would be impossible for that branch of the industry to stand on its feet for some time, and the need for "foster parents" was great. Under proper conditions it would be possible to make as cheaply as our enemies and to turn out a better article.

Sir Herbert Jackson, K.B.E., like the President of the Society was a confirmed optimist as to the future of the industry. At present the war provided the necessary stimulus for polling together. After the war national prestige must be the stimulus. We must have an honest pride in ourselves, and feel it intolerable to take second place. Each section of the industry must help the others, for knowledge gained in one branch is often valuable in another. An enormous amount of knowledge has been accumulated, and the time is very near for representatives of various branches to get together and shape problems of experimental work before the war ends so that work can proceed at once. The whole field of research must be viewed and care taken to prevent overlapping of research. A conference under the auspices of the Society of Glass Technology, in collaboration with a Government department, would be the surest and best method of tackling the problem. Giving Government help and protection it will be the fault of the industry itself if it does not thrive, and industry can ensure this by organising and by every one polling together.

Mr. R. S. Biram, of the Ministry of Munitions (Optical Branch), paid tribute to the great help given by the glass industry in the production of war material under difficult conditions. He predicted more difficult times ahead, as there was bound to be a further call-up of labour together with a shortage of materials and fuel. He advocated more concentration in works, and deplored lack of enterprise in certain quarters, because if industry was to progress it must show great enterprise.

Dr. W. Rosenhain, F.R.S., stated that the future of the industry after the war was of great importance, and what that future would be was not a foregone conclusion. Much had been done to meet the requirements of war, but would the stimulus last? Unless it does it is doubtful whether any measures will give the desired results. Given the necessary stimulus and motive power what the industry then required to be successful was method. There must be full utilisation of scientific results in the works and free interchange of knowledge between the scientist and the worker. Petty jealousies must be removed. There must be no extension of concentration to the exclusion of co-operation, because a great deal was to be gained by housing different branches of the industry under one roof. It might be possible to establish an industry by "fostering" it, but the child must grow and learn to be independent.

Mr. S. N. Jenkinson spoke of the great future in front of the glass industry if only it were allowed to develop. After the war much reconstruction of material and training of labour would be necessary, and the industry would require help. He traced much of the decline of the industry in the past to national apathy and even in certain quarters to actual antagonism. The glass trade must make itself efficient because it could not ask for assistance in the bolstering up of an efficient industry. The machinery of a Government department must all be efficient, and he made an appeal for the continuation after the war of the optical and glassware branch of the Ministry of Munitions.

Messrs. Congreve, Jackson, Redfern, Butterworth, Bagley, Thomas, Towers, Watmough, Kitson, and Proctor all joined in the discussion.

Finally, a resolution was drawn up as to the policy of the Society, and it was decided to circularise the same to the members for consideration and to note upon it at the next meeting, which will be held in Sheffield on June 19, 1918.

Before the meeting the members of the Society paid a most instructive and interesting visit to the works of Messrs. Ediswan, Ltd., at Ponder's End, and were afterwards entertained at lunch by the firm. The kindness of Messrs. Ediswan was much appreciated by all.

BRITISH ASSOCIATION OF CHEMISTS.

Meeting at Birmingham.

A meeting of the Birmingham section of the British Association of Chemists was held at the University of Birmingham on Thursday evening, May 23, Mr. E. W. Smith, M.Sc., F.I.C., presiding over a good attendance. In the circular it was pointed out that important decisions affecting the profession were about to be made by the

whole of the chemists of the country, and an invitation to vote on a ballot card, which was enclosed, to those unable to attend was given. The voting was open to (1) any person holding a university degree (or its equivalent) with chemistry as a principal subject; and (2) any person who could show evidence satisfactory to the Council of having had a sufficient general education and of having practised pure or applied chemistry for not less than seven years and who now held a responsible position. The resolutions were as follows:—

1. "That the proposals of the Institute of Chemistry, ratified by the Institute's Extraordinary General Meeting on April 27, 1918, reasonably meet the suggestions of the British Association of Chemists' Inaugural Meeting in Manchester on November 10, 1917.
2. "Are you in favour of the continuance of the B.A.C. after local sections of the Institute of Chemistry have been formed?"

The meeting was also asked to consider a third resolution as follows:—

"That the Provisional Society of the British Association of Chemists shall continue in being until—

(1) Local sections of the Institute have been formed;
(2) New regulations for admission to the Institute have been put into force;
(3) The new regulations for nomination and election to the Council of the Institute have been formulated and adopted by the Institute.

In the meantime, all chemists who support the proposals, as indicated in the third report of the B.A.C., shall be considered as eligible for membership of the Provisional Society of the B.A C., it being understood that such membership carries with it no obligation on the part of the B.A.C. or the Institute."

The CHAIRMAN explained that the meeting of the B.A.C. called for January 31 was postponed, and a national meeting would take place in Manchester on June 15. The Executive Committee, recognising the difficult of getting a gathering thoroughly representative of the profession, deemed it wise to adopt an all-round policy and to hold general meetings in the large local centres at which Resolution 1 and 2 should be considered. It was felt that what the Institute had agreed to met the demands made on November 10. There was a diversity of opinion as to whether they could accept the promise of the Institute as being sufficiently definite to justify the dropping of the B.A.C. He was officially informed that there might be much delay in putting into force the new regulations of the Institute in view of the alterations to be made to the Charter, and as they might have to wait until Christmas it seemed to him that it would not be wise now to drop the B.A.C. There was any amount of opportunity for change of opinion, and many had unquestionably altered their opinions considerably since they commenced the organisation of chemists. Those on the Executive who were in favour of the B.A.C. continuing were not in favour of it continuing to act as a "ginger-group" to the Institute, but felt that it should act with different functions which were not in opposition to the Institute. They were, for the most part, trades union functions. While they had sympathy in any movement for the "bottom dog" he did not think that the method of fighting, through the B.A.C. as modified, could be for the good of the professional chemist. There was a proposal that they should become linked with the Amalgamated Society of Engineers, and, if need be, adopt strike methods. He did not regard it as a sound or practical proposition either from the engineers' point of view or their own. The future of the qualified chemists and of juniors who wished to become such could more effectually be improved by other means—for instance, by qualified men in charge of other chemists, by banding together to see that only qualified juniors were taken on, that their education was properly supervised, and that adequate facilities were given by which they could obtain a sound and satisfactory training. If chemists in responsible administrative positions would show a determination to use their influence with their firms in order that every qualified chemist was adequately remunerated there would be no difficulty in increasing the salary level; but it would be necessary to differentiate between the qualified chemist and the unskilled man in the laboratory before there could be such advocacy on really effective lines. The danger of the trades union policy was that the prescribed minimum wage often became the maximum. There was a moderately large body of opinion in favour of the continuance of the B.A.C. as a political association having no connection with registration; but the reply to that was that the local sections of the Institute would give the necessary "ginger" to the Institute Council.

Resolution No. 1 was moved by Mr. HERAPATH, who insisted that on several important points, in relation to admission to the Institute, the Council were taking a broader and more favourable view than hitherto. There was no doubt that the Council were determined that the local sections should be living bodies.

Mr. H. T. PINNOCK, seconding, thought full confidence might be placed in the Institute recommendations. He regarded the position as satisfactory and largely due to the energy of the representatives on the National Council.

Mr. JOHNSON inquired what evidence there was that the Institute was looking favourably on the non-university trained man.

The CHAIRMAN pointed out that the B.A.C. was only a provisional body, and there was really no approved membership; but it was important to remember that the B.A.C. started out with very sound and definite qualifications. There was, indeed, no attempt to reduce the qualification standard.

Mr. MUNROE said, while considerable opposition was offered by the older members of the Council to a broadening of the basis of the Institute of Chemistry, the Council appeared to have made up their minds that anyone who could show a moderate amount of training—they appeared to lay greater stress on education than actual chemical training—would be admitted to the Institute.

There was no discussion on Resolution 2 in view of the third resolution, which was moved by Dr. PARKER.

The voting by ballot resulted as follows:—

Resolution No. 1—Carried; 97 votes for, 5 against.
Resolution No. 2—Defeated; 70 against, 27 for.
Resolution No. 3—Carried; 41 for, 1 against.

The CHAIRMAN announced that a meeting would be held shortly in Birmingham to elect the Local Council. All members of the Institute will be invited to attend the first meeting, and those, not members, who thought they were eligible, were advised to make application as soon as possible. The B.A.C. would not cease to exist in Birmingham fo some time.

Royal Institution.—A *General Meeting* of the Members of the Royal Institution was held on the 3rd inst., Sir James Crichton-Browne, M.D., F.R.S., Treasurer, in the Chair. A Resolution of Condolence was passed on the decease of the Duke of Northumberland, K.G. F.R.S., the President for nineteen years. The Duke of Northumberland, William Rintoul, and Arnold Jacob Cohen-Stuart were elected Members.

Physical Society.—The next meeting of the Society will be held on Friday, June 14, 1918, at 5 p.m., at the Imperial College of Science, Imperial Institute Road, South Kensington, London, S.W. A discussion will take place on "The Teaching of Physics in Schools," to be introduced by Sir Oliver J. Lodge, Principal of the University of Birmingham. Visitors are invited to attend this meeting of the Society.

CORRESPONDENCE.

SOCIETY OF YOUNG SCIENTIFIC STUDENTS.

To the Editor of the Chemical News.

SIR,—For some time past the undersigned have had in mind the desirability of the existence of a society of young scientific students for mutual help. We feel sure that there are a number of enthusiastic students of science who, like ourselves, have to rely chiefly on their own efforts for their progress in science, and we think that it would be of great advantage to them if they could co-operate in such matters as the purchase of apparatus, materials, and books, and for mutual help. There is no society which fully provides for these, and we have determined, after careful consideration, to endeavour to get into touch with some of this class of students. In order to do this we have ventured to ask you to kindly insert this letter in your columns. Will those interested please communicate with Mr. P. E. Owens, 28, Jesse Terrace, Castle Hill, Reading?—We are, &c.,

J. A. BUTLER,
P. E. OWENS.

REGISTRATION OF UNIVERSITY ELECTORS.

To the Editor of the Chemical News.

SIR,—May I ask for the hospitality of your columns for the purpose of urging graduates of the Universities of Durham, Manchester, Liverpool, Leeds, Sheffield, Birmingham, and Bristol to write to the Registrars of their respective universities for the forms of application for registration as electors.

The relatives of those graduates who are serving in the army or navy are urged to obtain the forms of application and to forward them to the graduates concerned.

I should like to point out that all graduates serving overseas will be able to vote, either by post or, in the case of those too far away, by appointing a proxy to vote on their behalf.

Further particulars relating to the University Franchise will be gladly sent to any applicant.—I am, &c.,

HERBERT G. WILLIAMS, Hon. Secretary.

The Combined Universities Conservative and Unionist Association, 130, Ashley Gardens, London, S.W. 1.
May 21, 1918.

POST AS CHEMIST IN ITALY.

To the Editor of the Chemical News.

SIR,—I should be greatly obliged if any correspondent could give me information on the following case:—

A lady chemist, who has been engaged on explosive work for a considerable time, is anxious to obtain a post as chemist in Italy, either with a private firm or on explosive work for the Government.

I should be very grateful for any information you could give me as to who to communicate with in England on the best method for the obtaining of such a post.—I am, &c.,

J. C. F. LISTER.

The Grove, London Road, Grays, Essex,
May 23, 1918.

METHOD FOR BOILING AT A HIGH TEMPERATURE.

To the Editor of the Chemical News.

SIR,—I am wanting to dissolve a material by *boiling*, which requires a heat of about 2500—3000° F. Can you or any your readers tell me how to do this, and what kind of vessel to use?—I am, &c.,

JOSEPH HUMBLET.

19, Dudley Road, West Bromwich,
May 22, 1918.

DETERMINATION OF MANGANESE IN STEEL.

To the Editor of the Chemical News.

SIR,—Noting Mr. Shipko's letter (CHEMICAL NEWS, cxvii., 204), with proper discretion in quick tests as applied to steel analysis the gravimetric method should always be applied when there is doubt; these cases so often arising from the number of possible causes of error in laboratory tests that any likely error should be adduced as a possible cause of error, and hence the importance of your columns being open to such communications as the above, especially important now in the interest of chemists.—I am, &c.,

J. C. THOMLINSON, B.Sc.

MISCELLANEOUS.

The Medal of the Society of Chemical Industry.—The above honour has been fittingly conferred upon Sir James Dewar, F.R.S., in recognition of the value of his researches in pure and applied science, particularly in the domain of the chemical industry. Sir James Dewar is one of the few men whose scientific activities do not appear to have been hindered by the war, and the value of his labours in the chemical industry is unquestionable.

Gift for Agricultural Research.—Mr. W. B. Randall, of Waltham Cross, has generously provided funds for the establishment of a new research post at the Rothamsted Experimental Station, and the Committee have appointed Mrs. D. J. Matthews, M.Sc., formerly Miss A. Isgrove. Mrs. Matthews is an Honours graduate of the Victoria University of Manchester, where she gained the Platt Biological Scholarship and the Dalton Biological Scholarship; she afterwards carried out important investigations at the Marine Biological Station, Plymouth. Her work at Rothamsted will consist in the study of some of the problems connected with soil sterilisation as it is now being carried out in certain types of nurseries.

What's in a Name?—The Röntgen Society is considering the advisability of changing its name, not altogether because Röntgen is a German professor, who, incidentally, has divested himself of all his British honours, but also because the name no longer covers the whole sphere of operations of the Society, which is now concerned with many other things besides X-rays. It is one thing, however, to divest yourself of your name, and a different thing to get another. The Ray Society sounds piscatorial or else occult. And if you must have a man's name in the title of a society there is only one Englishman who had enough to do with the discovery of X-rays to justify his inclusion. He is Sir William Crookes. But a Crookes Society has obvious objections, for the title would lend itself so easily among the blasphemous to that of the society of crooks.—*Amateur Photographer.*

Students of Chemistry and Military Service.—The Registrar of the Institute of Chemistry has received the following letter from the Board of Education:—

SIR,—I am directed to refer to your letter of the 2nd inst. forwarded by the Board of Trade to this Office and to state that the Board of Education have been informed that *instructions have been given by the* National Service Department to defer, for the present, the calling up of any student of chemistry attending a teaching institution recognised by the Board of Education or the Scotch Education Department who has not been or is not placed in Grade I., and produces a certificate from the Principal of the Institution that he has passed his Matriculation or corresponding examination, and is taking a full course of study in Science, including chemistry. The Board further understand that calling up notices (including any already issued) may, if necessary, be suspended for fourteen days, for production of this certificate.—I am, Sir, your obedient Servant, (Signed) J. G. MILNE.

New Oil Well in Mexico.—Another new oil well has just been brought in in the Alamo district near Panuco (Mexico), which at a depth of 2115 feet yields about ten thousand barrels daily. The first indication of oil was encountered at 1860 feet. This is only one of many wells being drilled by foreign concerns, and is regarded as proof of the belief of the owners in the stability of conditions and satisfaction with the petroleum laws.—*Mexican Notes*, May 2, 1918.

SPECIAL NOTICE TO SUBSCRIBERS.

We regret to announce that the recent paper restrictions will compel us for a period, until we can secure our usual supply of paper, to publish the Chemical News fortnightly instead of weekly.

The price will not be altered, except as regards the subscription price, which, until further notice, will be calculated at £1 for fifty-two numbers, or *pro rata*.

Subscribers will please note that the respective expiration dates of their subscriptions will be extended accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their extended subscription periods.

The next issue (No. 3050) will be published on June 21st.

To comply with Regulation 8 (*b*) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Analytical Chemist, Lady or Gentleman, experienced in Analysis of Foods, &c., required as Assistant in important London Laboratory.—Write, stating age, qualifications, experience, and salary expected, to "Foodanal," care of Deacon's Advertising Offices, Leadenhall Street, London, E.C. 3.

Analytical qualified Chemist, of either sex, required immediately to take charge of Laboratory of a London Dairy Company. Salary according to qualifications and experience.—Write, giving full particulars, to "Dairy," care of Street's, 30, Cornhill, E.C. 3.

Chemist wanted, or Man accustomed to Chemical production, for shift work in controlled factory. One used to Analysis. Ineligible, discharged soldier preferred. Permanency. State full particulars and salary required.—Address, S. M., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Engineering Chemist required by large fuel consumer to carry out Research Work on all classes of Fuels and to deal with Water problems. Salary £150 to £200 according to qualifications.—Address, E. C., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Metallurgical Chemist for Controlled Works on North-East Coast, with sound knowledge of the Analysis of Copper Alloys. Must have had experience with quick Electrolytic Methods of Analysis. The vacancy offers excellent post-war prospects to a really live man who is not afraid of work. No applicant will be considered under twenty-four years of age.—Write, giving full particulars of experience, stating age and salary required, to the nearest Employment Exchange, mentioning the Chemical News and No. A 5151. No one at present on Government work need apply.

Junior Assistant wanted for routine testing in Chemical Laboratory 10 miles North of London. Must be ineligible for Army. State salary required and experience.—Address, R. T., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Youth (16) requires berth in Analytical or Experimental Laboratory. Experience.—Address, Compton, 93, Commercial Road, S.E. 15.

Young Gentleman, ineligible for Military service, desires responsible Position in Chemical Manufacturing, Merchant, or allied business. Preferably, but not essentially, with view to subsequent interest in same. Thorough chemical experience and sound business capabilities; also practical agricultural experience.—Address, Y G, Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Works Analytical Chemist required. One conversant with Soap Manufacture, Nicotine Extractions, and Agricultural and Horticultural Preparations. State full particulars and salary required.—Address, W. A, Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted for the Laboratory of large Chemical Factory engaged on War work, well-trained and experienced Analysts. Accurate and systematic workers required. Vacancies exist for both Senior and Junior positions, male and female.—Address, "S. 11," Chemical News Office, 16, Newcastle Street, Farringdon Street, London, C. 4.

The Owners of BRITISH PATENT No. 15355 of 1914, entitled "Detonating Fuse," are desirous of disposing of the Patent or entering into working arrangements under licence or otherwise with firms likely to be interested in the same.

A copy of the patent specification and full particulars can be obtained from and offers (for transmission to the owner) made to MARKS and CLERK, 57 and 58, Lincoln's Inn Fields, London, W.C. 2.

IMPORTANT TO CHEMICAL MANUFACTURERS.

Messrs. FULLER, HORSEY, SONS, and CASSELL are instructed by the Corbyn Manufacturing Company, Ltd., to invite Tenders for the purchase of the recently erected

LANOLINE EXTRACTION PLANT

at their Works in Hunt's Lane, Stratford. The Plant includes 24 Enamelled Cast-iron Mixing Pans, 21 Jacketted ditto, 5 Enamelled Cast-iron Jacketted Pans, 2 Ingersoll Air Compressors with Steel Receivers, Cylindrical Steel Heating Tank with Coil, 3 Electric Motors, numerous Steel and Earthenware Tanks, Shafting, Belting, &c., &c.; also

TWO 8ft. x 33 ft. LANCASHIRE BOILERS,

100lbs. W.P. with three Injectors, Nicholi weir-type Feed Pump Steel and Earthenware Piping and Valves, Electric Ventilating Fan, 10 cwt. Weighing Machine, Earthenware Fitter, Single Purchase Crab, Office Furniture, including a Remington Typewriter, &c., &c.

Tenders should be delivered at the Offices of the Auctioneers, by 4 p m, on Monday, June 24th

Note.—The Purchaser will have an option of taking for an assignment of the Lease of the Company's Works on payment of costs.

The Plant may be inspected by Orders to be had of Messrs. CREWDSON, YOUATT, and HOWARD, Chartered Accountants, 70a, Basinghall Street, E.C. 2, or of Messrs. FULLER, HORSEY, and Co., Mechanical Auctioneers and Valuers, 133, High Holborn, W.C. 1.

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Messrs. W. HEFFER and SONS, Ltd., Booksellers, CAMBRIDGE, will be glad to receive offers of secondhand Books and Journals, for which they are prepared to offer full market price and pay cash. Particularly complete sets or long runs of the following:—

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THE CHEMICAL NEWS

Vol. CXVII., No. 3050.

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The next issue (No. 3051) will be published on July 5th.

DECOMPOSITION OF WATER BY METALS.

By DESMOND GEOGHEGAN.

I. The metals which decompose water at ordinary temperatures are :—

Metals of the Alkalis.

1 .. .. Potassium	4 .. .. Rubidium
2 .. .. Sodium	5 .. .. Lithium
3 .. .. Cæsium	

Metals of the Alkaline Earths.

6 .. .. Calcium	8 .. .. Barium
7 .. .. Strontium	9 .. .. Radium

II. The following are some of the more important metals which decompose water at a high temperature :—

1 .. .. Zinc	16 .. .. Manganese
2 .. .. Beryllium	17 .. .. Iron
3 .. .. Magnesium	18 .. .. Cobalt
4 .. .. Cadmium	19 .. .. Nickel
5 .. .. Scandium	20 .. .. Chromium
6 .. .. Yttrium	21 .. .. Molybdenum
7 .. .. Cerium	22 .. .. Tungsten
8 .. .. Lanthanum	23 .. .. Uranium
9 .. .. Didymium	24 .. .. Tin
10 .. .. Erbium	25 .. .. Titanium
11 .. .. Ytterbium	26 .. .. Zirconium
12 .. .. Samarium	27 .. .. Thorium
13 .. .. Aluminium	28 .. .. Germanium
14 .. .. Gallium	29 .. .. Antimony
15 .. .. Indium	

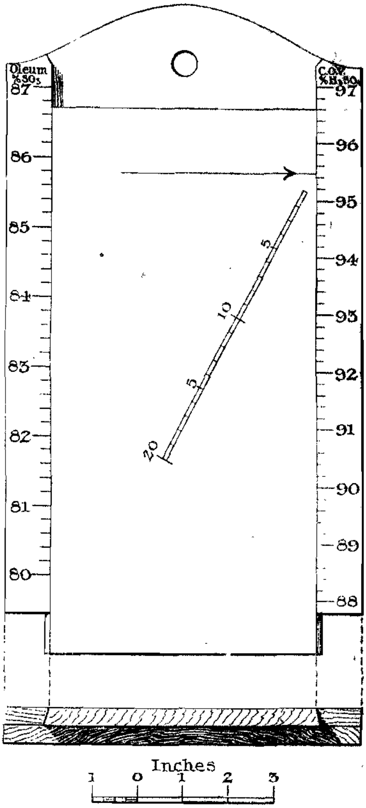
GRAPH FOR ACID MIXING.

By ERNEST C. CRAVEN.

It is a common practice in works using sulphuric acid in quantity to prepare acid of high concentration by mixing oleum and C.O.V. The proportions required are calculated from the laboratory report on the store tanks. The C.O.V. is usually expressed as per cent H_2SO_4 and the oleum as per cent SO_3.

The graph described here was devised for the purpose of obviating this calculation, and avoiding the bother of referring to tables. It proved a very practical time-saver.

Our specimen was made of three-ply wood with varnished paper scales pasted on. It consists of a panel sliding



between two side scales. One of the side scales is marked with C.O.V. concentrations and the other with oleum strengths, both on the same scale—*i.e.*, unit length on each corresponding to the same per cent difference of SO_3. The sliding panel bears a line which joins any two corresponding points on the side scales (or would join if

the scales were produced) — *e.g.*, 100 per cent H_2SO_4, 81·63 per cent SO_3.

This *line* is divided in 100 parts or otherwise conveniently sub-divided. By setting the end of this line to the *desired mixture strength* and laying a straight edge—or better, a taut thread across the side scales at the *laboratory report figures—the relative proportions of* oleum and C.O.V. can be read off on the divided line.

The result is, of course, in relative weights of C.O.V. and oleum, but no practical error results from reading volumes instead of weights. Indeed, it is usually convenient to sub-divide the line on sliding panel according to the dip of the standard charge for mixing tank, providing this has a constant cross section. The sketch shows a graph arranged for a 37" charge of 95·5 per cent acid.

It will be perceived readily that the principle of the graph depends on similar triangles, and various devices, such as extra side scales, reversing the panel, &c., will suggest themselves to the user.

THE NEUTRAL AMMONIUM SALTS OF ORGANIC ACIDS AND THEIR SUBSTITUTED DERIVATIVES.*

[Seventh Communication].

By LE ROY McMASTER and LETA WRIGHT.

(Concluded from p. 210).

Sulphonic Acids.

The literature mentions a few ammonium salts of the sulphonic acids prepared in aqueous solution, but their properties are very inadequately described. Having never applied our general method to the preparation of ammonium salts of this class of acids, we turned our attention to the preparation of some of them. Our results show that they can thus be readily made.

Ammonium m-*Nitrobenzenesulphonate.* — Limpricht (*Ann.*, 1875, clxxvii., 73) describes this salt as crystallising in clear leaflets without water of crystallisation, but gives nothing further of its properties. We prepared this salt in an ether solution as a white bulky non-crystalline compound. The salt dries quickly in the air and is very stable. It is not deliquescent, and does not give off ammonia in moist air nor in dry air at any temperature up to 100°. At this temperature there is no evidence of any decomposition. The salt is soluble in water, to which it imparts a neutral reaction for at least several days. We could not prepare it in an ethyl alcohol solution on account of its solubility in that solvent. The salt is slightly soluble in methyl alcohol, and insoluble in chloroform, ether, and acetone.

Calculated for $C_6H_4(NO_2)SO_3(NH_4)$—Ammonium N, 6·36 per cent; found—6·37 per cent.

Ammonium m-*Aminobenzenesulphonate or Ammonium Metanilate.*—It was found that the acid is insoluble in ether and soluble in alcoholic ammonia. The ammonium salt was probably formed, but would not precipitate on account of its solubility in the ethyl alcohol. After saturating this alcohol solution with ammonia an attempt was made to precipitate the salt by adding an excess of ether. A white colloidal product resulted, which could not be filtered even on an alundum crucible. The mixture was allowed to stand for a number of days, and, after the ether had evaporated, a clear yellowish solution remained. Upon further evaporation the alcoholic solution became darker in colour and finally turned red. No crystals separated until practically all the solvent had evaporated, whereupon large dark red thick plates appeared. They gave a neutral reaction when dissolved in water. This aqueous solution, which was reddish in colour, did not hydrolyse until it had stood for two days. The salt was stable at ordinary temperatures and slowly decomposed in dry air at 50°. It was decomposed readily in moist air.

Calculated for $C_6H_4(NH_2)SO_3(NH_4)$—Ammonium N, 7·37 per cent; found—7·38 per cent.

Ammonium 1.2.4-*Nitrotoluenesulphonate.* — Jenssen (*Ann.*, 1874, clxxii., 232) mentions this salt, but tells nothing about it except that it crystallises in long fine needles and is not decomposed at 190°. An attempt was made to precipitate it in ethyl alcohol, because it was thought that a better crystalline form could be obtained from alcohol than from ether. But though there was some precipitation it took place very slowly and very incompletely. The free acid was found to be insoluble in ether, but the ammonium salt came out beautifully when a suspension of the acid in ether was saturated with ammonia. The white precipitate was amorphous in form, and all of the free acid was converted into the salt. There was a slight amount of heat generated in this precipitation. This is unusual, for it has been found that almost always there is no heat generated when ether is used. The salt is not deliquescent. In dry air at 50° there was evidence of some decomposition of the salt after thirty minutes, but the rate was not much increased when the temperature was raised to 100°. Moist air decomposed it slowly. It was found to be slightly soluble in methyl alcohol, still less so in acetone, and insoluble in ether and chloroform. It is slightly soluble in ethyl alcohol. The aqueous solution is neutral and does not hydrolyse readily.

Calculated for $CH_3.C_6H_3(NO_2)SO_3(NH_4)$—Ammonium N, 5·98 per cent; found—6·02 per cent.

The ammonium nitrotoluenesulphonate is less stable than the nitrobenzenesulphonate, but in other ways the salts resemble each other. The ammonium nitrotoluenesulphonate has a peculiar odour which is not noticeable with the ammonium nitrobenzenesulphonate.

Ammonium 1.4-*Naphthylaminesulphonate.*—The ammonium salt of this acid known as naphthionic acid is not mentioned in the literature. It was found that the acid is a very insoluble substance. A suspension of the acid in ethyl acetate was used for making the ammonium salt. It was easy to see it changing over to the salt, for the acid is a chalky white amorphous powder, while the ammonium salt is pinkish brown in colour and possesses a distinct crystalline form. Ammonium naphthionate is soluble in methyl and ethyl alcohols and warm water. It is only slightly soluble in cold water. In solution it gives a red and blue fluorescence, which is characteristic of the salts of naphthionic acid (Piria, *Ann.*, 1851, lxxviii., 31). The lead salt crystallises in small red grains, while the crystals of the ammonium salt are small pinkish brown grains. The ammonium salt forms a neutral aqueous solution which does not hydrolyse within three hours. The salt is stable in dry air at 50°, but after thirty minutes at 100° there is a faintly perceptible change imparted to the colour of sensitive red litmus-paper. Moist air causes the salt to give off ammonia. It does not deliquesce.

Calculated for $C_{10}H_6(NH_2)SO_3(NH_4)$—Ammonium N, 5·83 per cent; found—5·86 per cent.

Ammonium 1.4-*Naphtholsulphonate.*—There is no reference to this salt in the literature, though a number of other salts of the free acid, which is called "Neville, Winther's acid," have been investigated (*Ber.*, 1880, xiii., 1949; *Ann.*, 1893, cclxxiii., 107). The acid is a very insoluble substance, but methyl alcohol and ethyl alcohol dissolve it slightly. The salt is very soluble in methyl alcohol, but was precipitated by adding to the solution ten times its volume of anhydrous ether. It was almost impossible to free the salt of the excess of solvent. It rapidly decomposed in dry and in moist air at ordinary temperatures, and its water solution, though neutral for about three minutes, quickly hydrolysed and gave an acid reaction. The salt is a light brown powder, a "cocoa" coloured substance, while the free acid is slightly pink. By the

* From the *Journal of the American Chemical Society*, xl., No. 4.

time the salt was thoroughly dry (a period of several days) analysis showed that it had greatly decomposed.

The salt was also prepared in a benzene suspension of the acid, and the same brown coloured powder was obtained. It dried very much more readily than the methyl alcohol product, but it gave off ammonia very rapidly. It was analysed a few hours after it was made, and the results showed that it had then more than half decomposed, although it had been either in a vacuum desiccator or in a tightly stoppered bottle during the meantime. At first a water solution of the freshly prepared salt showed a neutral reaction, but it soon hydrolysed. The salt is insoluble in ether, chloroform, acetone, ethyl acetate, and benzene.

Ammonium 1.5-*Naphtholsulphonate*.—It was thought best to prepare this salt from an ether suspension, since it was found that it was, like the 1.4-salt, very soluble in methyl alcohol, which is the only medium in which the free acid is easily soluble. The salt was quickly filtered and dried. It dried quickly to a finely-divided brownish powder, an aqueous solution of which gave a neutral test for a period of ten minutes. Dry air at ordinary temperatures does not decompose it within a period of fifteen minutes, but after that it does. It quickly decomposes at 50° in dry air, and moist air at ordinary temperatures decomposes it readily.

Both this 1.5-salt and the salt of Neville, Winther's acid are very soluble in methyl alcohol, somewhat soluble in ethyl alcohol, and insoluble in ether, ethyl acetate, benzene, chloroform, and acetone. The 1.4-salt is also insoluble in acetic acid, while the 1.5-salt shows a slight solubility in this medium. This latter salt, as well as the former, lost ammonia so readily that one analysis showed only 2·25 per cent N. The correct value is 5·81 per cent.

Other Acids.

Ammonium Benzilate.—There is no record of this salt ever having been prepared, though other salts of benzilic acid have been studied (Symons and Zincke, *Ann.*, 1874, clxxi., 131). The free acid is soluble in methyl and ethyl alcohols, ether, and ethyl acetate, but ammonia will not precipitate the salt from any of these solutions. In ether a precipitate did form at first as an amorphous white powder, but on addition of more ammonia this changed to a sticky half-transparent mass, which in turn dissolved when still more ammonia was added. Finally, a benzene suspension was treated with ammonia. The fine white needles of the free acid were very rapidly changed over into a yellowish mass exactly like that encountered in one stage of the ether solution treatment. This mass did not change in appearance materially for a period of three hours, during which time ammonia was constantly bubbled through the solution. At the end of that time the flask was removed and stoppered. It was allowed to stand for two days, and then small transparent crystals were seen distributed over the bottom and sides of the flask. The mass that had been soft and sticky had become hard, and when broken up it was found to consist of the same small granular crystals which coated the flask. These crystals were filtered and dried in a vacuum for a short time, and tested for neutrality and stability. Their aqueous solution was neutral. They are not deliquescent. Moist air slowly decomposes the salt, and dry air at 50° causes it to lose ammonia after thirty minutes.

Calculated for $(C_6H_5)_2C(OH)CO_2(NH_4)$—N, 5·71 per cent; found—5·71 per cent.

This diphenylhydroxyammonium acetate resembles very much more closely the salts of phenylacetic acid and its substituted derivatives than it does that of glycolic acid itself. It has been found by one of us that ammonium phenylacetate and the substituted phenylacetates are stable salts, some of which are yellowish in colour; they give off ammonia slowly in moist air, and they can all be prepared in alcohol. This is not true of the benzilate, and that

benzilate and glycolate itself. Ammonium glycolate rapidly loses ammonia in the air and is hygroscopic (McMaster and Magill, *Journ. Am. Chem. Soc.*, 1916, xxxviii., 1788). Also a water solution of ammonium glycolate hydrolyses very readily, and one of ammonium benzilate does not.

Ammonium Oxanilate.—This salt has been prepared and some of its properties studied (Laurent and Gerhardt, *Ann.*, 1848, lxviii., 20; Aschan, *Ber.*, 1890, xxiii., 1821). It is described as plates, slightly soluble in cold water and cold alcohol, but very soluble in hot water and hot alcohol. It is also stated that it begins to lose its ammonia at 190°.

The neutral salt can be precipitated from an ether suspension of the acid in the form of a curdy mass or as a flaky precipitate from a methyl or ethyl alcohol solution of the acid. Considerable heat was developed when the ammonia was passed into the alcohol solutions, and it was necessary to keep the solutions cold. Flaky yellowish white crystals precipitated. When perfectly dry the salt is composed of fine white needles.

The salt is soluble with difficulty in cold water, to which it imparts a neutral reaction. The aqueous solution does not hydrolyse. It is only slightly soluble in methyl and ethyl alcohols, and insoluble in acetone, ether, and benzene. The salt is not deliquescent, and gives off no ammonia in dry air until heated above 100°. Laurent and Gerhardt found that at 190° this salt began to lose ammonia, and at the same time a little aniline was formed, and finally there remained oxanilide. On gently heating we also found aniline to be formed. In moist air ammonia is slowly given off.

Calculated for $NH(C_6H_5)CO.CO_2(NH_4)$ — Total N, 15·38 per cent; found—15·36 per cent.

Ammonium Phenylpropiolate. — Phenylpropiolic acid, which contains a triple bond, is the first acid of its type whose ammonium salt has been studied in the laboratory of Washington University. There is no record of the salt having been made elsewhere. It was precipitated in an ether solution of the free acid. A little heat was developed during the saturation with ammonia, which is an unusual occurrence with ether solutions. The salt is a pure white powder having a slight odour. It is somewhat soluble in ethyl alcohol, very soluble in methyl alcohol, and insoluble in chloroform, acetone, benzene, and ether. An aqueous solution is neutral for about two hours, after which time it slowly hydrolyses and gives an acid reaction. Moist air causes it to lose ammonia, but in dry air at 50° it remains unchanged for about one hour before it begins to lose ammonia slowly. This salt is not hygroscopic.

Calculated for $C_6H_5C{:}CCO_2(NH_4)$—N, 8·59 per cent; found—8·62 per cent.

Work is still in progress in this laboratory on the ammonium salts of organic acids

BUILDING AFTER THE WAR.

THE Committee of the Ministry of Reconstruction which is making an inquiry throughout the country from local authorities, builders, architects, and others as to the probable demand for, and supply of, building materials during the reconstruction period two years after the war, has extended, until July 1, 1918, the date upon which the Inquiry Forms already sent out are to be returned.

The Committee hopes that any authority, person, or firm contemplating building works immediately after the war who has not received one of the Committee's Forms of Inquiry will apply either directly or through an architect to the Secretary of the Building Materials Supply Committee, 6A, Dean's Yard, Westminster, for a Form.

In cases where only sketch plans have been prepared and the preparation of complete plans and bills of quanti-

hostilities, it would appear that no materials will be required until at least six months after the war, and as regards these works it will suffice if the under-mentioned particulars are furnished:—

County.
Description of building.
Estimated pre-war value of the work.
Estimated date of commencement of building.
Estimated duration of contract.

Wherever possible, however, approximate quantities of materials needed should be furnished, especially in the case of building-stone and bricks, steel, and timber.

Materials needed for repairs, maintenance, &c., form the subject of a special inquiry, and particulars of these are not needed at present. In other matters, however, it is hoped that every effort will be made to complete Forms of Inquiry by the date specified. Unless the Committee is made fully aware of the prospective needs of consumers it will not be possible to estimate how far the available supplies will meet the demand, and its efforts to secure co-ordination may thus prove unsuccessful.

ORDERS OF THE MINISTRY OF MUNITIONS.

Copper Sulphate.

Whereas the Minister of Munitions desires to amend the Copper Sulphate Order, 1918, in manner hereinafter appearing.

Now, therefore, in exercise of the powers conferred upon him by the Defence of the Realm Regulations and of all other powers enabling him, the Minister of Munitions hereby orders as follows:—

1. The maximum prices fixed by the Copper Sulphate Order, 1918, shall not apply to any sale or purchase effected after the date of this Order of copper sulphate guaranteed in writing by the vendor to be specially purified and to contain a specified percentage of copper sulphate, being not less then 99 per cent.

2. The maximum prices at which, after the date of this Order, sales and purchases of finely-ground copper sulphate in powder form may be effected shall be those specified in the Copper Sulphate Order, 1918, with the following additions, namely:—

10s. per ton in the case of sales and purchases of 2 cwts. or upwards.
½d. per lb. in the case of sales and purchases of 28 lbs. and over but less than 2 cwts.
¾d. per lb. in the case of sales and purchases of 1 lb. and over but less than 28 lbs.

3. This Order may be cited as the Copper Sulphate (Amendment) Order, 1918.

Note.—All applications in reference to this Order should be addressed to the Director of Acid Supplies, Ministry of Munitions, Department of Explosives Supply, Storey's Gate, S.W. 1, and marked "Copper Sulphate."

Compound Fertilisers.

The Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm Regulations, and of all other powers enabling him, hereby Orders as follows:—

1. This Order shall take effect as on and from June 5, 1918.

2. For the purpose of this Order and the Schedules hereto, the following expressions shall have the following meanings:—

"Potash" shall mean compounds of potassium calculated as potassium oxide soluble by the methods prescribed by the Fertiliser and Feeding Stuffs (Method of Analysis) Regulations, 1908.

"Compound Fertiliser" shall mean any fertiliser, or substance intended or sold for use as a fertiliser (however described or named), which is manufactured or made by mixing or compounding together, artificially, any two or more separate substances. Provided that the product obtained by treating with sulphuric acid, or any similar reagent, a single substance containing nitrogen phosphates and potash, or any one or more of such constituents, shall not be regarded as a compound fertiliser for the purposes of this Order.

"Unit" shall mean 1 per cent by weight in 1 ton of fertiliser.

"Maker of Compound Fertilisers" shall mean a mixer or compounder of any compound fertiliser as above defined.

3. For the purposes of this Order the maximum prices for compound fertilisers shall be as follows:—

(*a*) In the case of sales for delivery free on rail, cart, barge, or ship at maker's works, the basis price for compound fertiliser of the description sold to be arrived at as provided in Clause 7 of this Order with the addition of a charge for mixing or compounding, bags and bagging, not exceeding 25s. per ton, and with the addition also (in the case of sales of less than 2 tons) of the extra distribution charges authorised under Paragraph (*b*) (i.) of this clause in the case of sales of similar quantities *ex* vendor's store or shop or *ex* warehouse.

(*b*) In the case of sales for delivery elsewhere than at maker's works the maximum prices authorised under Paragraph (*a*) above for sales of quantities of 2 tons and upwards for delivery free on rail at maker's works with the following additions, namely:—

(i.) In the case of sales for delivery *ex* vendor's store or shop, or *ex* warehouse (other than maker's store or warehouse at point of manufacture), the following extra distribution charges according to the quantity of compound fertiliser included in the sale, namely:—

Quantity sold.	Additional price authorised.
1 ton and over	10s. per ton
2 cwts. and over but less than 1 ton	1s. per cwt.
1 cwt. and over but less than 2 cwts.	2s. ,,
28 lbs. and over but less than 1 cwt.	3s. ,,
Over 14 lbs. but less than 28 lbs. ..	4s. ,,

(ii.) In the case of sales for delivery *ex* railway goods yard or public wharf, an extra distribution charge at the rate of 2s. 6d. per ton of compound fertiliser included in the sale. Provided that this additional charge shall not be made in the case of sales of more than 1 ton.

(iii.) In the case of all sales for delivery elsewhere than at maker's works all costs of transport of the compound fertiliser from maker's works to place of delivery, and cartage or haulage to be charged at not exceeding local rates.

4. On sales of 2 tons and upwards by makers to agricultural merchants and dealers or to co-operative companies and societies incorporated or registered under the Industrial and Provident Societies' Act, or any other Act, the maximum prices fixed by Clause 3 of this Order shall be reduced by a discount or allowance to the purchaser, such discount to be 5s. per ton where the maximum price of the compound fertiliser (after deduction of such discount) is less than £6 per ton, and 7s. 6d. per ton where the maximum price (after deduction of a 5s. discount) is £6 per ton or upwards.

5. The maximum prices fixed by this Order are net cash prices for compound fertiliser in maker's or vendor's bags or other packages, net weight excluding weight of bags. Where credit is given to the purchaser a reasonable extra charge may be made, provided that the discount allowed for net cash is quoted on the invoice, and is such as to bring the net cash price within the maximum authorised.

If purchaser's bags or other packages are used or the purchaser takes delivery in bulk without bags a reasonable allowance shall be made to the purchaser. Where compound fertiliser is sold for delivery in bags (other than paper-bags) containing less than 2 cwt. each, an extra charge of 4d. per bag may be made beyond the maximum price which would otherwise have been authorised.

6. The maximum prices fixed by the foregoing provisions of this Order are for sales of compound fertilisers for delivery during December, 1918. In the case of sales of compound fertilisers for delivery during other months, the maximum prices are in each case to be reduced or increased 1s. 6d. per ton per month, according as the month for delivery precedes or is subsequent to December, 1918, but with a maximum decrease and increase of 7s. 6d. per ton; *e.g.*, the maximum prices for sales of compound fertilisers for July, 1918, delivery will be 7s. 6d. less per ton, while the maximum prices for sales for May, 1919, delivery will be 7s. 6d. more per ton than the maximum prices fixed as above for sales for December, 1918, delivery.

7. For the purposes of Clauses 3 and 9 of this Order the basis price for any compound fertiliser shall be the aggregate value of the nitrogen, phosphates, and potash contained in the compound fertiliser when valued at the respective unit rates specified in the first schedule hereto, and distinguishing in the case of nitrogen between the two classes of nitrogen, and in the case of phosphates, between the three descriptions of phosphates, also specified in the first schedule. In arriving at such basis price nothing shall be allowed or added for the value of any constituents of the compound fertiliser other than nitrogen, phosphates, and potash.

8. As on and from the date on which this Order takes effect no person shall sell or purchase or offer to sell or purchase any compound fertiliser at a price exceeding that prescribed by this Order as the maximum price (having regard to quantity, composition, packages, date for and terms of delivery) for such sale. Provided that—

(*a*) A vendor of compound fertiliser shall not be liable to conviction for selling at a price in excess of the maximum price prescribed by this Order if the invoice given to the purchaser, as required by Clause 9 of this Order, states accurately within the limits of error allowed by that clause the percentages of the different constituents therein referred to contained in the compound fertiliser sold and the price charged and stated on such invoice does not exceed the correct maximum price on the basis that the percentages stated in such invoice are correct; and—

(*b*) A purchaser of compound fertiliser shall not be liable to conviction for purchasing at a price exceeding the maximum price unless the price agreed to be paid by him is to his knowledge in excess of the maximum price authorised for such purchase.

9. As on and from the date on which this Order takes effect, no person shall sell any compound fertiliser without giving to the purchaser on or before or as soon as possible after delivery an invoice stating:—

(*a*) The percentage contained in such compound fertiliser of each of the following constituents contained therein, namely:—(i.) Class I., Nitrogen; (ii.) Class II., Nitrogen; (iii.) Water Soluble Phosphate; (iv.) Citric Soluble Phosphate; (v.) Insoluble Phosphate; and (vi.) Soluble Potash, all as more particularly defined in the first schedule hereto (such percentages to be stated accurately in the case of each constituent within the limits of error specified in the second schedule hereto;

(*b*) The maximum unit rates authorised to be charged for each of such constituents as specified in the first schedule hereto;

(*c*) The basis price for such fertiliser in which may, however, be included any charge made for credit;

(*d*) All addition made to such basis price in arriving at the actual price charged for such fertiliser (including the maker's charge, not exceeding 25s. per ton for mixing or compounding, bags and bagging); and

(*e*) The price charged for the compound fertiliser, and where such price includes an extra charge for credit, the discount allowed for net cash.

10. None of the foregoing provisions or restrictions of this Order as regards maximum price or otherwise shall apply to:—

(*a*) Any sale of any compound fertiliser for export from the United Kingdom to any country other than the Channel Islands or the Isle of Man.

(*b*) Any sale of any compound fertiliser in quantities not exceeding 14 lbs.

(*c*) Any sale of compound fertiliser in quantities exceeding 14 lbs., where the compound fertiliser is sold for horticultural purposes, packed in special bags, tins, boxes, or cartons, each branded or marked with the maker's or vendor's name and address, and the words "Horticultural Fertiliser," and containing not more than 14 lbs.

(*d*) Any sale of any compound fertiliser for delivery prior to July 1, 1918.

11. As on and from July 1, 1918, no person [illegible] facture or produce any compound fertiliser, [illegible] maker of compound fertiliser sell any [illegible], except under a licence issued by or under the [illegible] of the Minister of Munitions, and in accordance with any terms and conditions of such licence.

12. All persons engaged in producing, making, selling, distributing, or storing any compound fertiliser shall make such returns with regard to their businesses, and shall verify the same in such manner (including production of their books to any accredited representatives of the Minister of Munitions) as shall from time to time be required by or under the authority of the Minister of Munitions.

13. None of the foregoing provisions or restrictions of this Order shall apply to a sale, by a maker to a consumer, of two or more fertilisers or substances, neither of which is by itself a compound fertiliser as defined by this Order, notwithstanding that it is one of the terms of the purchase that the fertilisers or substances purchased are to be artificially mixed or compounded together by the maker before delivery, provided that such fertilisers or substances are sold separately by description as such, and that an invoice is given to the consumer on or before or as soon as possible after delivery which states the quantity and price of each of the fertilisers or substances included in the mixture or compound as delivered, and the charge made for mixing or compounding bags and bagging.

14. This Order and the Fertilisers and Feeding Stuffs Act, 1906, shall operate and have effect independently of one another, and nothing contained in this Order shall be held to exempt any person from compliance with any of the provisions or requirements of such Act, or any Regulations made thereunder, applicable to sales or purchases of compound fertilisers; nor shall any of the provisi[illegible] the said Act or Regulations be held to govern or affect [illegible]y of the requirements or provisions of this Order, or any proceedings instituted in respect of any breach thereof.

15. This Order supersedes the Orders relating to compound fertilisers made by the Minister of Munitions on October 13, 1917, and November 14, 1917, excepting only as regards sales or purchases of compound fertilisers made before or after the date of this Order for delivery before June 1, 1918.

16. This Order may be cited as "The Compound Fertilisers Order, 1918."

NOTE.—All applications in reference to this Order should be addressed to the Director of Acid Supplies, Ministry of Munitions, Department of Explosives Supply, Storey's Gate, Westminster, S.W. 1.

The First Schedule.

(Unit rates of nitrogen, phosphates, and potash for the purpose of the above Order).

PART 1.—*Nitrogen.*

Class 1.	*Unit rate.*
Derived from sulphate of ammonia, salts of ammonia, nitrate of soda, or other salts of nitric acid, cyanamide, meat, blood, bone, slaughterhouse refuse, ground horn, ground hoof, guano, fish offal, fish meal, fish guano, oilseed cakes or meals, or dissolved shoddy, dissolved wool waste, or dissolved silk waste as below defined..	18s. 6d.

(NOTE.—The expression "dissolved shoddy," "dissolved wool waste," and "dissolved silk waste" shall mean shoddy wool waste and silk waste treated with sulphuric acid or any similar reagent in such a way that at least 80 per cent of the fibre is destroyed).

Class 2.	Unit rate.
Derived from other sources	7s. 6d.

PART 2.—*Phosphates.*

Description.	Unit rate.
"Water Soluble," *i.e.*, rendered soluble in water	4s. 3d.
"Citric Soluble," *i.e.*, insoluble in water, but soluble in a 2 per cent solution of citric acid in the manner prescribed by the Fertilisers and Feeding Stuffs (methods of analysis) Regulations, 1908	2s. 6d.
"Insoluble," *i.e.*, insoluble either in water or in a 2 per cent solution of citric acid in the manner prescribed by the said Regulations ..	1s. 6d.

PART 3.—*Potash.*

"Soluble," *i.e.*, soluble by the methods prescribed by the said Regulations	25s. 0d.

The Second Schedule.

(Limits of error referred to in Clauses 8 and 9 of the above Order).

Nitrogen Class 1..	0·3	—
Nitrogen Class 2..	0·3	—
Phosphate water soluble ..	1	—
Phosphate citric soluble ..	1	—
Phosphate insoluble	1	—
Potash soluble	0·3 (*a*)	0·5 (*b*)

(*a*) If the percentage of potash stated in the invoice does not exceed 4.

(*b*) If such percentage exceeds 4.

(NOTE.—The above figures for limits of error represent percentages of the whole bulk of the compound fertiliser).

June 4, 1918.

MINISTRY OF RECONSTRUCTION.

COMPULSORY ARBITRATION DISAPPROVED.

THE Whitley Committee on the Relations between Employers and Employed have presented a further report which is now published by Dr. Addison, Minister of Reconstruction. It deals with conciliation and arbitration. The Committee pronounce definitely against any system of compulsory arbitration, on the grounds that it is not generally desired by employers and employed, that it has not proved a successful method of avoiding strikes during the war, and that it would be less likely to be successful in time of peace. They also pronounce against any scheme of conciliation which would compulsorily suspend a strike or lockout pending an enquiry.

The Committee advocate the continuance, however, of the present machinery for voluntary conciliation and arbitration, and hope that the setting up of Joint Industrial Councils (on the lines recommended in their earlier reports) will tend to the growth of such machinery. They consider that there should be means for holding independent enquiry into the circumstances of a dispute and for making an authoritative pronouncement thereon without the compulsory power of delaying the strike or lockout. Their main constructive suggestion is that a Standing Arbitration Council should be established on the lines of the present temporary Committee on Production. To this Council disputants would be able voluntarily to refer such differences as they are themselves unable to settle.

It is suggested, however, that single arbitrators should be available for less important cases which could be heard locally. It is further suggested that the Standing Arbitration Council should take means to secure the co-ordination of arbitrators' decisions. The Committee are opposed to the enforcement of awards and agreements by means of monetary penalties.

The report is available from H.M. Stationery Office, Imperial House, Kingsway, W.C. 2, price one penny.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, May 16, 1918.

Sir J. J. THOMSON, O.M., President, in the Chair.

PAPERS were read as follows:—

"*Certain Coloured Interference Bands and the Colours of Tempered Steel.*" By A. MALLOCK, F.R.S.

After alluding to the interference bands seen when two rows of posts, &c., or two gratings are viewed one through the other, the paper deals with a particular case of such bands, namely, that when a plate of dispersive material, such as glass, is placed between the two gratings, or, which amounts to the same thing, when a single grating is placed on a thick mirror, and the interference takes place between the grating and its reflective image.

The bands so formed are coloured. The composition of the colours in terms of primary red, green, and violet is given diagrammatically by means of Maxwell's chromatic triangle for nine examples. It is noticed that the sequence of colours in some of these agrees closely with those of tempered steel.

It is shown that the colours of tempered steel are not "colours of thin plates," and it is suggested that they must be due to the formation of some material whose molecular period is comparable to the period of light waves and not to a structure comparable with the wave-length.

"*General Factors in Mental Measurements.*" By J. C. M. GARNETT.

An enquiry into the mathematical argument for the existence of Prof. Spearman's general factor g, in all mental abilities of which measurements had been published during many years, led to an investigation into the consequences that must follow from the condition that the correlation between every pair of columns in a correlation table is ± 1.

These consequences were found to be that there is one and only one factor common to all the qualities whose correlations form the table; that there are no group factors common to two or more qualities but not to all; and that there may be any number of specific factors each belonging to one quality only.

It was found that any quality which is distributed according to the normal law, and depends only on n independent factors (qualities), say, $x_1 x_2 \ldots x_n$, which are distributed according to the normal law and which have the same standard deviation, may be represented by—

$$g = l_1 x_1 + l_2 x_2 + \ldots + l_n x_n,$$

where—

$$l_1^2 + l_2^2 + \ldots + l_n^2 = 1.$$

The standard deviation of q, moreover, will be the same as of $x_1 x_2 \ldots x_n$.

The existence is indicated of a third general factor c ("cleverness") independent both of Prof. Spearman's g ("general ability"), and of Dr. Webb's w ("purpose").

How much would be known concerning the mental qualities of an individual whose g, w, and c had been measured is discussed in concluding the paper.

"*Absorption of X-rays in Copper and Aluminium.*" By C. M. WILLIAMS.

The paper deals with the relation between the mass absorption coefficients of X-rays in copper and aluminium and the respective wave-lengths over a range of 0·431—0·637 A.U. Homogeneous rays were produced by the interference method, a rock-salt crystal being used to analyse a beam of X-rays generated by a Coolidge tube. Precautions were taken that the reflected beam consisted of a pure radiation, waves of a higher order than the first being eliminated.

The difficulty encountered by the variation in intensity of the source was obviated by using a "double" ionisation chamber. By means of this the beam reflected from the crystal was divided into two parts, one of which was used to standardise the variations in intensity of the other, upon which the absorption experiments were made. Very consistent results were obtained, separate determinations not differing by more than 1 per cent.

The relation between the two absorption coefficients are examined, and the dependence of each of the latter on the wave-length. A notable feature is the occurrence of discontinuities in the curves representing the results; these may probably be connected with the J-series recently described by Barkla.

With respect to the approximate relation between the mass absorption coefficient μ/ρ and the wave-length λ given by the equation $\mu/\rho = a\lambda^n + C$, where a, n, and C are constants, it appears that, while the relation is fairly well satisfied in the case of copper by giving n the value $5/2$—a result in conformity with Owen's 5th-power absorption—the results for aluminium show a value $n = 3$.

"*Electrical Resolution and Broadening of Helium Lines.*" By T. R. MERTON, D.Sc.

1. The broadening of helium lines by condensed spark discharges is in close agreement with the electrical resolution of the lines.

2. The "isolated components" in the electrical resolution which have been recorded by Brunetti, and by Takamine and Yoshida, have been found in the broadened lines.

3. An explanation is offered of the relative degree of broadening of lines of the "arc" and "spark" type, on the supposition that the latter acts as a kind of safety valve to the former when the intensity of excitation becomes very great.

4. It is suggested that the "isolated components" are not a direct product of the electrical resolution, but are in reality an extension of the helium spectrum. Two of these lines may, perhaps, be represented as lines of combination series.

PHYSICAL SOCIETY.

Ordinary Meeting, May 10, 1918.

Prof. C. H. LEES, F.R.S., President, in the Chair.

A PAPER on "*The Times of Sudden Commencement of Magnetic Storms*" was read by Dr. S. CHAPMAN.

The paper is a discussion from a new standpoint of the data, collected by Dr. Bauer, for 15 magnetic storms. Maunder's work on the recurrence of magnetic storms at intervals equal to the rotation period of the sun suggests that storms are due to some solar agent transmitted along narrow well-defined streams, issuing from and rotating with the sun. This suggests the view that the relative time of commencement of a storm at different stations depends mainly on the orientation of the latter at the time, relative to the sun; *i.e.*, on the local time at the station. This forms the basis of the classification in the paper.

DISCUSSION.

Dr. CHREE said that after hearing the paper he was uncertain whether Dr. Chapman did or did not believe that the figures *proved* anything. He (Dr. Chree) did not think that they did. To deal with a question of a few seconds' difference at different stations, it would, be thought, be desirable to employ not merely a more open time scale, but magnetographs of greater and desirably uniform sensitiveness. When a magnetic change became recognisable depended on the size of the movement and the sensitiveness of the magnetograph. An apparent difference in time between day and night hemispheres would naturally arise if movements tended to be larger in the one than the other. One objection which he had urged against Dr. Bauer's views also applied to the hypothesis considered by Dr. Chapman, viz., that as soon as a disturbance began at any part of the earth's atmosphere it would naturally be propagated by electromagnetic waves to other parts. He was not aware of any direct evidence confirmatory of Dr. Chapman's statement that atmospheric currents causing the diurnal variation were mainly situated in the comparatively near neighbourhood of the station. Also, even if this were the case, he did not see that any inference could be drawn as to what happened in the case of so different a phenomenon as a "sudden commencement." We did not even know whether the electrical currents causing the two phenomena were at the same level in the atmosphere. "Sudden commencements" were sometimes large, 50γ or even 100γ. They were not instantaneous changes, the rise normally seen in horizontal force in ordinary latitudes taking usually four or five minutes to attain its full value, a curious feature being that the high value was generally retained for some time, sometimes, in fact, for several hours, especially at stations in certain latitudes. A consideration of the exact nature of the phenomena was a desirable prelude to any theorising. On the historical question which Dr. Chapman had raised, as to the discovery of a tendency to "repetition" in magnetic storms, it was very natural for him as a Greenwich man to emphasise the really valuable work which Mr. Maunder had done in this connection, but it was only fair to remember the much earlier work of Broun, and the independent work of A. Harvey and the late Prof. Birkeland. One reason why a belief in the "repetition" of magnetic storms had advanced so slowly was that sun-spot theories had been so often suggested by cranks that they were naturally somewhat suspect. In the case of magnetic disturbances, and Mr. Maunder's Greenwich lists were no exception to the rule, the great majority did not have a "sudden commencement," and opinions as to when the average storm began or ended might differ by several hours. It was thus in general impossible to assign an exact value to the interval between two storms. Further, what one man called a "storm" another did not, so where one might see a "repetition" another would not. A further complication was the existence of a diurnal period in disturbance data, representing partly statistical imperfections and partly a real natural phenomenon. Dr. Chapman did not seem to realise that the twenty-seven day period was just as manifest as in disturbed conditions. It was also important to remember that it had presented itself in years like 1913, when sunspots were almost non-existent, just as decisively as in years of many sunspots.

Prof. NEWALL said that when Maunder's results were first brought forward it was felt to be a difficulty that they should involve an almost geometrical recurrence; because, of course, the disturbances on the surface of the sun were travelling with varying periods. When the slide

showing the periodic recurrence of certain storms was first shown by Maunder it was noted that a 1 per cent difference *in the adopted rotation period would change the* direction of the lines which indicated coincidence of period to 45° from the vertical. One saw on looking at the slide that there were many cases in which lines at different angles would suit. No one familiar with eclipse phenomena could doubt, however, that something originated in the sun. Many of the streamers sent out from the corona seemed quite straight, and it was difficult to resist the idea that sometimes the earth would be at the other end. Had *Dr. Chapman considered the difficulty raised by Kelvin* of the necessary energy relations? The energy of the magnetic storm itself might be attributed to something abstracted from the energy of rotation of the earth by the particles after entering the atmosphere.

Father CORTIE thought Maunder was the first to connect the twenty-seven day period with the solar streamers. There seemed to him to be a difficulty about these streamers of charged particles. Schuster showed that owing to the *mutual repulsion of the charges the stream would be* dispersed. He did not think that any particular storm was associated with a particular sunspot, but with a disturbed area of the sun which might extend many degrees. His idea was that the dispersed streamers from the disturbed regions formed clouds of particles, and that the earth may enter such a cloud, giving rise to magnetic storms. From the table it seemed to him that there was a slight preponderance of effect on the night side relative to Greenwich—*i.e., over the Pacific Ocean. Would the presence* of a large expanse of water be likely to affect the phenomena?

Mr. T. SMITH asked why the times of sudden commencement were chosen. He would imagine that similar time relationships would hold for any prominent feature. One would normally expect greater irregularities just at the beginning of the storm than when it was well under way. When it was known that a storm had commenced, wide scale *runs* could be started and *measurements made* on some subsequent outstanding feature.

A MEMBER asked what irregularities might be due to lag in the different instruments used in the different observations.

Prof. LEES said that when Dr. Chree first brought the matter before the Society he had set some of his students to work out the correlation factor of Bauer's figures. The factor was so low that there was evidently no basis what *ever for Bauer's theory.*

Dr. CHAPMAN, in reply, said he did not put any reliance on *the actual figures given in the paper*. The observational error was too great. It was the method of treating the observations that he thought was of importance. He thought diurnal variations were produced at lower levels of the atmosphere than storms. By "near neighbourhood" he meant within about 1000 kilometres or so. He did not think Maunder connected the storms with actual sunspots, but *rather with disturbed regions*. Of course, any proper motion of the disturbed region on the sun would alter the period *in particular cases; but in examining a long series* it was best to take the synodic period since the others would be distributed on either side of this. He had not yet gone into the energy question, but did not think that this would present any insuperable difficulties. He did not think the streams would diffuse very much. He thought they consisted of α-particles. They did not *necessarily proceed* radially from the sun, but might emerge in all directions from radial to tangential. This, however, would not seriously affect the time taken to pass across the earth. There was a definite reason for choosing the commencement times of the storms. When the storm is under way the magnetic state of the earth is fluctuating, and it is difficult to recognise accurately particular features. There was certainly a lag in the measurements which differed in different instruments; but the effect of this was greatly reduced in the present method of grouping the observations, since the same instrument on different occasions contributes results to different groups. In this respect the method has a great advantage over classifica*tion on a geographical basis, in which case any instrument* is always in the same group.

A paper entitled "*The Entropy of a Metal*" was read by Dr. H. S. ALLEN.

An expression for the entropy of 1 grm. atom of a substance in the *solid state has been given by Ratnowsky*. In a communication to the Physical Society in 1916 the author gave the correct form of the approximation required for high values of the absolute temperature in terms of Bernoulli's numbers. The data required for testing the formula have been supplied in a recent paper by Lewis and Gibson, who have given values for the entropy of the *elements under the condition of constant volume, and also* under constant pressure. These values were deduced from observations on the specific heat assuming the truth of the heat theorem of Nernst, that the entropy of every actual substance in the pure state is zero at the absolute zero of temperature. It is found that the formula of Ratnowsky gives values for the entropy of a solid in very close agreement with those obtained by Lewis and Gibson. The hypotheses assumed in the theory of Ratnowsky are discussed, and the conclusion is drawn that these are probably justified as being at least approximately true.

A paper, entitled "*On Tracing Rays through an Optical System*," was read by Mr. T. SMITH.

FARADAY SOCIETY.

Ordinary Meeting, May 7, 1918.

Sir ROBERT HADFIELD, Bart., F.R.S., President, in the Chair.

THE PRESIDENT opened a general discussion *on "The Co-ordination of Scientific Publication."*

Sir Robert prefaced his remarks by saying that it was for the Conjoint Board of Scientific Societies to decide upon a policy, but he hoped that the discussion might prove helpful.

Federation of interests between scientific societies could be brought about without any new organisation. For example, papers which overlapped several societies should be brought before the members of all, although *only one* need publish them.

Both "*geographical*" and "*subject*" co-ordination had to be considered. The former should generally centre round the metropolitan society. As regards the latter, papers might be allocated by some central body, such as the Conjoint Board, which should also circulate weekly a classified list of papers to be read. Papers would thus ensure being discussed by those most fitted to criticise them.

Some particulars were given of the recently formed *German federation of six prominent technical associations*, comprising some 60,000 technical experts.

As a further illustration of valuable co-ordination, Sir Robert instanced the way in which certain metallurgical researches were recently organised and carried out in Germany and Austria. It was noteworthy how, in the latter instance, Ministers concerned co-operated in the organisation of the work.

He advocated the appointment of representatives of the *Empire on the councils of the various societies.*

Another striking example of co-operation was the great United Engineering Societies' Building in New York, in which were housed the four main engineering societies of the country and some score of smaller ones.

Prof. A. SCHUSTER, Secretary of the Royal Society, said it was necessary to distinguish between a scheme concerned with the reading of papers—to ensure consideration by authorities on the subject—and their publi-

cation. He advocated some kind of uniformity of type and size of journal as a preliminary to co ordination of publication.

Some kind of organisation between the big subjects, like engineering, physics, and chemistry, was not difficult, because there could be one central body composed of practically independent sections, something like the British Association.

The question of a great central library containing every scientific publication of standing ought to be considered in connection with the International Catalogue of Scientific Papers.

He hoped the Conjoint Board of Scientific Societies would publish a weekly or fortnightly list of all papers to be read before the societies.

Mr. Michael Longridge, President of the Institution of Mechanical Engineers, did not think that papers could be allocated to the different societies by a central body. One objection was the existence of prizes and medals offered by many societies. He supported Prof. Schuster's idea of a journal, which might also contain a short synopsis of the papers announced. Members of any affiliated society should be allowed to be present at meetings of any other society.

As regards the idea of a central library, what really was wanted was a "College of Librarians," where trained men could put inquirers on to the track of researches they desired to follow up.

He advocated the formation of local sections of all the engineering societies and local associations formed by co-ordinating these local sections.

Mr. C. H. Wordingham, President of the Institution of Electrical Engineers, thought that the pooling of papers would tend to stifle the individuality of the various societies, which had not sprung up without response to a need, and the quality of the papers would deteriorate. It was particularly in the indexing of papers that co-ordination was needed, and this led up to the suggested pooling of libraries.

If all societies published reprints in a uniform form, it would be easy for people to acquire and bind together all papers in which they were interested, wherever read. A general index would indicate where the papers could be obtained. Moreover, the larger societies might publish a general account of what they were doing.

Mr. Robert Mond mentioned the *Journal of the Society of Chemical Industry* as an example of the kind of co-ordination—local sections with a common journal—that had been advocated. The International Catalogue needed a card index to make it really useful, so that one could obtain cards on any particular subject. The "College of Librarians" would be another method of doing the same thing, and some such institution was becoming essential now that scientific work was being published in all languages. The central building in New York was an example of what was required, but the scientific as well as the engineering societies should come into the scheme, which would maintain the community of interest of all scientific workers.

Mr. W. R. Cooper emphasised the importance of maintaining the individuality and the traditions of the separate societies. Overlapping could be largely prevented by a system of reprints rather than by duplication of printing, and the societies should be careful to remain within their own preserves. Joint meetings would help to solve the problem of combining joint interests. He advocated the central library if only because it would avoid unnecessary duplication of books and periodicals.

Mr. L. Pendred, editor of the *Engineer*, supported the proposal to standardise the size of the publications of the technical societies. He criticised the central library scheme with the accompanying catalogue or index, on the ground that when a card index grows too large it becomes too complicated and loses its value. Sectional libraries would be more manageable, but he approved of Mr. Longridge's suggested "College of Librarians."

Mr. E. Worthington, Secretary of the Institution of Mechanical Engineers, agreed with the previous speaker as to difficulty in finding one's way about too comprehensive a library. Another objection would be the necessity still to have great provincial libraries. Sectional libraries connected with the various societies, properly staffed and connected by private telephones, was a preferable scheme.

As regards co-ordination of publication, a plan easy to start would be to have central places, in London as well as in other towns, where all papers and discussions published by the scientific and technical societies were indexed on a card index.

Mr. G. Shaw Scott, Secretary of the Institute of Metals, thought it would be useful if the American societies sharing the central building in New York were asked to tell us what they had done there in the direction of co-ordination and to prevent overlapping. The central building might perhaps familiarise people with the idea of the central board. In the meantime he supported the scheme for spreading information among the societies with regard to all papers to be read. The Institute of Metals published reprints of its papers, and their journal happened to be the same size as those of the Institution of Mechanical Engineers, the Iron and Steel Institute, and the Institution of Civil Engineers.

Mr. F. S. Spiers, Secretary of the Faraday Society, advocated informal discussions or consultations between the secretaries and editors of cognate societies when drawing up their programmes or arranging meetings, as a means towards co-ordination and preventing overlapping. It was too late to wait until papers were actually down for reading.

He advocated abstracting being carried out by a central body, say, the Conjoint Board, instead of by the numerous societies and journals which now did the work piecemeal. In this department there was at present very much overlapping that could easily be prevented. The abstracts could be issued in sections, and the separate sections sold for a small sum to members of affiliated societies. The Faraday Society published reprints of its papers.

Prof. R. A. Gregory, editor of *Nature*, in a communication which was read to the meeting, wrote that if a society or journal survived it was because it served a useful function. They could not therefore hope that there would be any reduction in the 601 scientific and learned societies of the United Kingdom, nor in the 1400 serials to be found in the libraries of London. The Royal Society's Catalogue and the International Catalogue, even with a complete index, would only help to solve the problem of co-ordination if all the literature thus indexed were easily available for reference. He therefore supported the scheme for a central library or bureau. Failing this, there should be a system of co-operation in the purchase of books by the existing libraries, which might be grouped together according to subjects covered, and a joint catalogue prepared. A proper scheme of abstracting could only be carried out in connection with a comprehensive central library.

Mr. J. G. Pearce presented a paper on the subject in which the following concrete suggestions were put forward:—

1. The development of a United Engineering and Technical Societies' Library from existing libraries, associated with the great State libraries.
2. The free admission and the right to participate in discussions of all members of all prominent societies, at all meetings of these societies.
3. Sale of Proceedings at a nominal charge.
4. Systematic preparation of text-books by experts under the guidance of the Department of Scientific and Industrial Research.
5. Development of schools of library science.
6. Welding of existing indexing agencies into one for technical science as a whole.

DR. CHARLES A. KEANE was of opinion that, preparatory to creating the big scheme that had been referred to, groups of allied societies, engineering or chemical, might take the first step from which fuller co-operation could follow. The individual societies should have full freedom of action with regard to papers; a well-ordered Publication Committee would naturally hand on to the proper quarter an unsuitable paper. On borderland subjects, however, there was room for more effective co-operation, and joint conferences should be more frequently arranged. He strongly supported standardisation in the size of Proceedings.

To prevent overlapping of abstracts, while the central journal was an ideal to be aimed at, an approach would be made if each group of societies had a journal of abstracts. The abstracts of the Chemical Society and the Society of Chemical Industry had been made mutually available to the members of either society. The fortnightly *Review* now published by the latter Society was another step in the direction of bringing the various societies in unison with one another, and he hoped the scheme would be extended. In that *Review* an account was given not only of papers and discussions but also of the deliberations of Councils and Committees.

MR. PERCY PEAKMAN read a note contributed by Miss Margaret Benson and himself dealing with the subject as it appeared to the research man in the factory. They thought that all the information on any one subject should be in the hands of one controlling authority, and the results of research, whether in works or universities, should be published if possible weekly side by side. Special sections of existing libraries all over the country could be organised for the co-ordinated publications.

MR. THOMAS WRIGHT spoke on systems of indexing, an important subject not properly understood by many people. He advocated the use here of the Dewey decimal system that was employed in the central library in New York.

DR. PERCY E. SPIELMANN, in a written communication, advocated the inauguration of an international scheme to deal with abstracts, each participating country working through its own central body, which should distribute its own abstracts as well as translations of those received from other countries.

The production of monographs should be encouraged as being the best method of co-ordinating facts in a short and semi-permanent form, capable of frequent revision.

DR. E. H. TRIPP, in a communication received after the meeting, considered that the problem of formulating a general scheme for scientific publication could not be divorced from the larger question of federating some of the societies themselves, and he was not hopeful as to the prospects of overcoming the present inertia. Two solutions of the co-ordination problem were possible, one between existing material, without elimination, and the more thoroughgoing method of the creation of a Central Board to be responsible for all publications that could be issued in sections to the different societies. If the system could not be altogether applied to papers on pure science, it was certainly practicable as regards abstracts of work in applied science. Beyond this there was scope for high-class journals to keep the worker in touch with progress in science generally. He feared that if action were not soon taken Government Departments might endeavour to gain control of scientific publication.

DR. JOHN O. TUNSTALL, in a written communication, distinguished between *co-ordination* and *co-operation*, which had been used as if synonymous. An excellent beginning would be made in co-operation if the thirteen or so homeless London societies housed themselves under one roof. As to co-ordination, he imagined the existence of a "Secretary of Secretaries," perhaps with a Special President and Council, who might be in touch with all the societies and be the fountain-head of intercommunication.

CORRESPONDENCE.

STEEL ANALYSIS.

To the Editor of the Chemical News.

SIR,—Could any of your readers oblige me by giving the author, date, and publishers of the latest, or some of the latest, publications on "Steel Works Analysis"?

The latest one I am able to find is Arnold and Ibbotson's "Steel Works Analysis," 1907, publishers of which are Whittaker and Co., White Hart Street, Paternoster Row.

I shall be very much obliged for any information on the subject.—I am, &c.,

GEO. B. HANSON.

251A, Waterloo Road, Hightown, Manchester.

THE CO-EXISTENCE OF MATTER AND ENERGY.

To the Editor of the Chemical News.

SIR,—Mr. F. A. Dugan, in the course of a paper on the above subject (CHEMICAL NEWS, 1917, cxv., 245), states:—"There is no thermal change when sugar is dissolved in water, no energy is set free, and none is absorbed."

Now, in the course of some experiments which I carried out some years ago I found that there is a very marked absorption of heat when sugar is dissolved in water, and, conversely, there must be a corresponding liberation of heat when the sugar crystallises again.

In some of my experiments 500 grms. of finely powdered sugar was dissolved with gentle stirring in 500 grms. water, both being initially at the same temperature. There was, in one of a number of closely agreeing experiments, a drop of 4·9° F., and correcting for the specific heat of the apparatus used this was equivalent to a disappearance of 6·7 B.T.U. per grm. sugar.

I also found that when a strong solution of sugar is mixed with water, both being at the same temperature, there is a very distinct rise in temperature, accompanied by shrinkage of volume.

In one experiment 500 grms. of 60 per cent sugar solution was mixed with 500 grms. water, giving a rise of 0·37° F. The evolution of heat varied with the concentration of the sugar solution, and consequently with the degree of shrinkage.

I used the F. scale because I wished the results in B.T.U.

These properties of sugar are well known. Reference to quite an extensive literature, extending back to Robert Boyle, 1680, are given in Lippmann, "Die Chemie de Zuckerarten," 1904, ii., 1162.—I am, &c.,

THOS. STEEL.

Sydney, N.S. Wales,
April 16, 1918.

THE BREAD AND FOOD REFORM LEAGUE.

To the Editor of the Chemical News.

SIR,—It gives me much pleasure to say that a Report pul lished by the Food (War) Committee of the Royal Societ on "Digestibility of Breads" confirms the great importanc of the movement for bread reform to which I have devote thirty-eight years of my life.

This important investigation on the digestibility of th 90 per cent extraction of wheat now adopted by th Government, results from a letter signed by influenti scientists and medical men, sent in May last year by th Bread and Food Reform League, asking the Food (Wa Committee to consider the advisability of urging the Foo Controller to encourage the consumption of finely-grou wholemeal containing about 90 per cent of the whe berry, as this percentage, which has been used with ve

satisfactory results in Government institutions for about forty years, would increase the amount of wheat available for a bread which experience proves is sustaining and satisfying.

The Report will be published as a Parliamentary paper, but in the meantime the following information is forwarded :—

Digestive experiments were conducted by the Food (War) Committee in the laboratories of Cambridge, Glasgow, and London Universities. Subjects for experiment, included men, women, and children, vigorous workers and invalids, and patients at two sanatoria for consumption. The bread made from the 90 per cent extraction of wheat proved palatable and digestible.

The Report deals with experiments carried out on a larger scale than has ever before been made in any country, and the following important conclusions were arrived at by the Food (War) Committee.

That by increasing the extraction of wheat in milling from 80 to 90 per cent :—

1. A gain of energy available for man would be obtained equivalent to an increase of about 1,700,000 million calories of energy on the wheat milled each year in the country before the war, or enough to extend the cereal supply of energy for more than one month.
2. A gain of protein available for man of 35 lbs. on each ton of wheat milled would be secured. This is equivalent to an increase of about 90,000 tons of protein on the wheat milled each year in the country.

A much larger increase would be shown if the comparisons were made with the pre-war 70 per cent bread.

The Report does not deal with the additional phosphates and vitamines secured by the adoption of the 90 per cent extraction of wheat, but the *Food Journal* issued by the Ministry of Food states that their scientific advisers consider that bread made from Government regulation flour has all round more nutritive properties than the pre-war supplies.

"First, the flour contains more lime, and is therefore better suited for growing children than fine wheaten flour; second, it contains a greater variety of proteins, and is therefore better calculated to meet the demands of the human body for the different food-stuffs of this class of which it is in need; third, it contains more 'germ,' which adds to the proteins and increases its content of fat; fourth, it contains more 'vitamines,' an indispensable class of substance about which our knowledge is not complete, but we know that a deficiency of these profoundly impairs nutrition."

It is very satisfactory to find that the facts, to which the Bread and Food Reform League has for so many years directed attention, have received such important confirmation, and I most gratefully appreciate the scientific and social support given to a movement which has now enabled the country to obtain a very great increase in food which provides energy and body-building material.—
I am, &c.,

MAY YATES,
Hon. Secretary and Founder of the Bread and Food Reform League.

37, Essex Street, London, W.C. 2,
May 16, 1918.

Temperature Conversion Table.—The Cambridge Scientific Instrument Co., Ltd., of Cambridge, have devised a very useful table for instantly converting the Fahrenheit scale into Centigrade or *vice versa*; from absolute zero to 2000° C. the scales are arranged in the form of a spiral and are very easy to read. The table is mounted on stiff varnished card for hanging in the laboratory, and the sides are filled in with useful data—melting-points, specific heats, densities, &c.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

NOTE.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxvi., No. 6, February 11, 1918.

New Methods of Determining Copper, Zinc, Cadmium, Nickel, and Cobalt.—Adolphe Carnot.—The salts of these metals are precipitated by alkaline carbonates, but this reaction has not been employed for their estimation owing to the fact that the precipitation is not usually complete. If, however, the following directions are followed the precipitation is quite satisfactory. It is first ascertained that the neutral or acid solution does not contain ammonia. If it does it must be evaporated to dryness, calcined, and redissolved. It is then neutralised in the cold with sodium carbonate in moderate excess, and the precipitate is redissolved in ammonia in slight excess. When the solution is heated to boiling complete precipitation occurs, and the precipitate may be filtered off and washed with hot or cold water. The precipitate is an oxide, hydrate, hydrocarbonate, or exceptionally a neutral carbonate. It is easily converted by calcination into an anhydrous oxide, or by reduction into pure metal; or if there is only very little material it may be transformed into neutral sulphate.

Mechanism of the Formation of Isomers of Cinchonine and their Hydrohalogen Derivatives.—E. Léger.—The author has recently shown that cinchonine and three of its isomers, cinchoniline, cinchonigine, and apocinchonine, give the same hydrobromo base when heated with HBr. The mechanism of the production of apocinchonine at the expense of cinchonine may be explained by assuming the intermediate formation of an oxydihydrocinchonine, the group $CH_2.CH.CH$ of cinchonine being changed into $CH_3.CHOH.CH$ by the fixation of water upon the vinylic double bond. On losing water this compound would give the group $CH_3.CH.C$, which is characteristic of apocinchonine. The fixation of HBr takes place at the double vinylic bond of cinchonine. It is evident that the fixation at the double bonds of cinchonine and apocinchonine and at the ether oxide bond of cinchoniline and cinchonigine would give rise to the same hydrobromocinchonine. The author believes that apocinchonine, cinchonigine, and cinchoniline have constitutions which differ from that of cinchonine. Cinchoniline and cinchonigine appear to be stereoisomers.

Examination of Mercury Fulminate and the Analysis of Mixtures for Detonators.—Paul Nicolardot and Jean Boudet.—Mixtures for detonators may contain antimony sulphide among other impurities, and may be analysed by first treating with ammonium hydrosulphide, which transforms the mercury fulminate into a red sulphide of formula HgS. Sulphide of antimony is completely dissolved by yellow ammonium sulphide, and may be reprecipitated as Sb_2S_3, free from sulphur, by means of ammonium sulphite.

Precipitation of Phosphoric Acid as Ammonium Phosphomolybdate. Practical Estimation of Phosphoric Acid by a Simple Nitrometer Measurement.—J. Clarens.—If the precipitation is carried out in presence of sufficient quantities of ammonium nitrate (0·1 grm. phosphoric anhydride dissolved in 10 cc. of water added to 100 cc. of the molybdic reagent in which 15—20 grms. of ammonium nitrate had previously been dissolved) a precipitate is obtained in which the ratio of ammonia to phosphorus is fixed. The phosphoric acid can thus be determined by estimating the ammonia, which can be performed by any gasometric method.

No. 7, February 18, 1918.

Estimation of Vanadium in Presence of Molybdenum by means of Titanous Chloride.—A. Travers.—Two specimens of steel are attacked as described in a previous communication. *In one the vanadium is determined* by adding KCNS before titanous chloride. The latter is added slowly, meanwhile carefully shaking, until one drop gives a persistent coloration. In the other specimen the vanadium and molybdenum are determined together, adding KCNS after reduction.

No. 8, February 25, 1918.

Critical Constants of Mercury.—E. Ariès.—The author has already worked out a formula for determining the critical constants of crypton, argon, and xenon, and has now applied it to mercury vapour, which is also monatomic. The results show that the critical temperature of mercury is about 1077°, while the critical pressure is about 420 atmospheres.

MISCELLANEOUS.

New Oil-containing Fruit.—A new fruit containing a large percentage of oil has been discovered in the region of Torreon, and is known by the name of "chichopoxtle." Experiments show that 25 per cent of its contents consist of oil of great value in *industrial pursuits requiring* a lubricant of high quality. It is proposed to introduce the cultivation of this fruit upon a large scale.—*Mexican Notes*, May 2, 1918.

Fibres resembling Fused Quartz in their Elastic Properties.—*Prof.* K. E. *Guthe*, Associate Physicist of the Bureau of Standards, Washington, gives an account of the preparation and properties of fibres of fused steatite or soapstone ($Mg_3H_2Si_4O_{12}$). It was desired to obtain threads of from 0·1 to 0·2 mm. in diameter and a metre long; such threads are somewhat difficult to prepare from fused quartz on account of the presence of air bubbles, which are not easy to remove from the comparatively large bead necessary. After trying several substances it was found that the material that is used commercially for the tips of gas burners and like purposes answered admirably, and had all the characteristic properties of fused quartz with the additional advantage that thick fibres do not so readily break. In the oxyhydrogen flame this substance fuses to a clear glass and can be formed into threads of the requisite dimensions. The elastic fatigue of such fibres is very small, about one-third that of steel or phosphor bronze. The linear coefficient of expansion was found to be −0·0000045.—*Bulletin of the Bureau of Standards, Washington*, i., No. 1.

Coolidge Tubes—"Broad Focus" Type.—We have received the following communication from Mr. F. U. Willcox, General Manager of the Lamp and Wiring Department, British Thomson-Houston Co., Ltd.:—It is desirable to point out that the "broad focus" type of Coolidge tube is the preferred type of tube for treatment work. The "broad focus" type is designed for heavy energy inputs, and is used almost exclusively for treatment and radiographic work, where large amounts of energy are required. By reason of the broad focus of this tube it will stand 80—90 milliampères backing up a 6" spark, and will also operate continuously using such lower amounts of energy as are necessary for treatment purposes. The customary amount of energy used for treatment work is 5 milliampères, backing up an 8" spark gap, and this tube is capable of handling this large amount of energy for whatever necessary period of treatment required. For prolonged treatment, however, using the above amounts of energy, *i.e.*, 5 milliampères, and 9" spark gap, it is always advisable to cool the bulb by means of a fan or blower. We are now arranging to carry a stock of these "broad focus" tubes.

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THE CHEMICAL NEWS

Vol. CXVII., No. 3051.

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The next issue (No. 3052) will be published on July 19th.

MAGNETIC SUSCEPTIBILITY AND ELECTRIC RESISTIVITY.

By F. H. LORING.

In the Chemical News (1914, cix., 121) a general account was given of magnetic susceptibility, together with tables of values for the elements.

In discussing the phenomenon of magnetic susceptibility it may be conducive to clearness to note at the outset that the term *ferromagnetic*, as applied to iron, cobalt, and nickel (magnetite, Fe_3O_4 or $FeO.Fe_2O_3$, is ferromagnetic, and ferro-cobalt, Fe_2Co, is also strongly magnetic), serves to distinguish these elements from practically all others which are weakly magnetic or which do not exhibit certain magnetic properties peculiar to iron.

Furthermore, the term *paramagnetic* may be applied to all the elements of Table II. in the citation above referred to, though by virtue of the subdivision just defined the term is frequently used in a restricted sense to designate the weakly magnetic elements of positive magnetic susceptibility standing in contrawise relation to those elements which are *diamagnetic*, especially since the latter are without exception weakly (dia-) magnetic. A few of the weakly magnetic elements having positive susceptibilities simulate iron in their magnetic behaviour, and it is possible that these may come to be regarded as truly ferromagnetic. Manganese, for example, can exist in two states, paramagnetic and ferromagnetic, exhibiting when in the latter state hysteresis phenomenon according to P. Weiss and H. K. Onnes (*Konink. Akad. Wetensch. Amsterdam Proc.*, xii., 649; also *Comptes Rendus*, cl., 686).

In order to comprehend the wide range of variation in the magnetic susceptibilities of the elementary substances (referred to as elements to distinguish them from compounds or mixtures), the values given in the tables in the above article may be plotted as a single curve shown by Fig. 1. It is to be noted that the curve is not drawn to proportionate scale and that only a few elements are inserted in the diagram, but all the known elements may be fitted into a curve of the type shown.

There are *three* characteristic parts to the curve which indicate a complexity of phenomena that may be due to certain fundamental variations in the atomic and molecular systems involved. It is proposed to treat the fundamental phenomena as a compound effect analogous to that of the joint resistance of parallel circuits or paths (a and b) according to the well-known rule:—

$$\text{Joint res.} = \frac{\text{res. of circuit } a \times \text{res. of circuit } b}{\text{res. of circuit } a + \text{res. of circuit } b},$$

but with this difference, that in addition a *negative* resistance is introduced which represents a negative current, so that the equation becomes, for example,—

$$(-a.b)/(-a+b) = (-\text{susceptibility});$$

i.e., when analysing the negative susceptibilities.

Resistivity, it will be remembered, is a term for *specific resistance*, being the reverse of *specific conductivity*, and resistance equals *potential difference* ÷ *resulting current*,

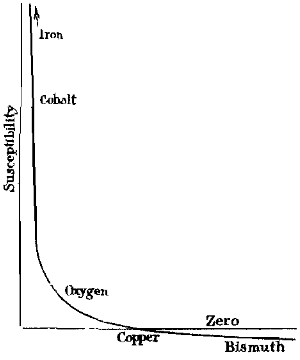

Fig. 1.

according to Ohm's law. The reason for the analogous procedure will be rendered obvious from the following considerations:—

It is supposed from indirect experimental evidence that *paramagnetism* arises from *molecular* currents, whilst *diamagnetism* arises from *atomic* currents. Not that the paramagnetic elements have no atomic currents, but that the molecular currents mask those of the atom so as to render their effect negligible, as in the case of iron, or ferromagnetic metals in particular. Quoting from Bidwell's article in the last edition of the "Encyclopædia Britannica":—"Diamagnetism, in short, is an atomic phenomenon; paramagnetism and ferromagnetism are molecular phenomena. Hence may be deduced an explanation of the fact that, while the susceptibility of all known diamagnetics (except bismuth and antimony) is independent of the temperature, and that of the paramagnetics varies inversely as the absolute temperature in accordance with the law of Curie." There are known deviations from the Curie law.

If the foregoing statement in general be true, then the specific resistance or electrical resistivity of elementary substances might have a conditioning or governing effect,

so that in analysing the phenomenon of magnetic susceptibility, the atomic or molecular currents expressed in terms of positive and negative resistivities would seem to supply the variables necessary to co-ordinate the complex magnetic effects under consideration. What is true of the substance in mass may be true of the substance in minute part—the atom and molecule in particular. Atoms themselves are supposed to be compressible, as they are in the aggregate (Richards). At or near the absolute zero of temperature metallic masses seem to approach the atom in at least one property, that of conductivity, but conductivity may not be entirely a self contained atomic or molecular phenomenon, since the degree or nature of contiguity of the atoms or molecules in solids may give rise to modifying conditions. Hence resistivity is probably a gross term as distinguished from a net term.

It can be shown that the orientations of a group of pivoted magnets will give rise to effects which can be expressed in terms of an electric current. Thus, in a general way, it might be argued therefrom that the magnetic susceptibilities of diamagnetic elements are dependent upon their electric resistivities and the atomic currents.

There is perhaps direct experimental evidence in support of the foregoing observation, since bismuth is the most diamagnetic metallic element, its mass susceptibility being $-1\cdot4\times10^{-6}$, and it has the highest electrical resistivity, namely, 119×10^{-6}. Antimony, also a metal, stands next

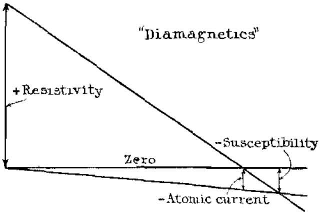

FIG. 2.

to bismuth in both properties. Copper, which is near the other end of the conductivity series for metals, is at the beginning of the negative susceptibility series (see CHEMICAL NEWS, cix., 121).

Mercury, a liquid at normal temperatures, however, is somewhat exceptional, but at very low temperatures when a few of its physical properties approach more nearly those of copper at ordinary temperatures, it has an exceedingly low relative resistance. In fact, very close to the absolute zero of temperature the resistance of mercury reaches the vanishing point; *i.e.*, its resistivity becomes zero.

Such being the case, and assuming that the resistance rule can be applied in the circumstance of diamagnetic elements, where $-a$ stands for a negative atomic current, and that—

$$(-a.b)/(-a+b)=(-\text{susceptibility}),$$

then the negative atomic current need not vary appreciably with temperature. This would lead to the conclusion that the negative susceptibility would be infinitely great at a critical point when in case of metals the resistivity proper is still appreciable. Probably, however, the current in effect decreases when a critical stage is reached.

Referring to Fig. 2, it will be seen that the diamagnetic elements will suffer very little change in susceptibility over a considerable range of temperature variation, which accords with facts.

With regard to the ferromagnetic elements, the state of affairs is somewhat different. The resistivities are intermediate, iron being about 10×10^{-6}. Therefore, the molecular currents, assumed in this case, must be enormous to account for the very high magnetic susceptibility. That the ferromagnetic elements should have the monopoly of such large molecular currents seems, however, improbable; consequently, by a converse analogy with respect to the diamagnetic elements it might be assumed that the conditions are such as shown by Fig. 3.

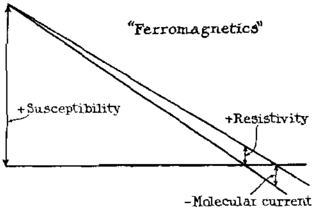

FIG. 3.

Referring again to Fig. 2, it will be seen that a slight variation of the resistivity would not appreciably alter the susceptibility until close to the zero temperature, whereas, in the case of Fig. 3, a slight variation in temperature, and therefore a variation in resistivity, would affect considerably the susceptibility, or in the case of slight variations in the molecular currents (including the masked atomic currents—see above) and the resistivity would

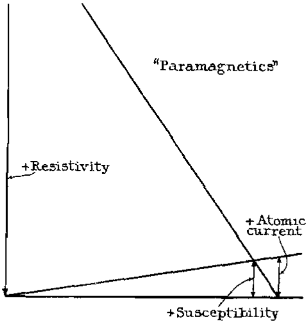

FIG. 4.

greatly affect the susceptibility. In the case of iron the permeability for small magnetising forces increases with a rise of temperature, slowly first and afterwards rapidly, until the iron is red-hot, when it suddenly falls to unity, the iron then becoming practically non-magnetic. Fig. 3 would predict such an action up to the critical point. (See "Magnetic Induction in Iron and other Metals," Ewing, Chapter VIII.).

The addition of 12 per cent of manganese and 1 per cent of carbon to iron produces a steel that is non-magnetic for

all practical purposes, being the well-known Hadfield's manganese steel. This steel is, by the way, about fifty times more magnetic than liquid oxygen, to quote a popular illustration.

While Fig. 3 does not predict such a result the presence of an element which changes the type—say, to that of Fig. 4—would be expected to lower the susceptibility.

Continuing the study of Figs. 2 and 3, the ferromagnetics have negative molecular currents, and they are associated with resistivities numerically less than the currents according to the scale of comparison involved in the diagram. The diamagnetics, on the other hand, have negative atomic currents, the resistivities being numerically greater than the currents. In the case of the ferromagnetics the molecular currents (these may be resultant currents) are of the same order of magnitude as the resistivities.

Thus it will be seen that the original ideas stated above, particularly those recorded by Bidwell, require practically no modification in principle when the peculiarities of the different cases are taken into proper account.

Oxygen stands as an intermediate type between the elements of very high susceptibility and those close to zero in magnetic value. It cannot be conceived that oxygen has molecular currents owing to its very high resistivity. It may have positive atomic currents, and at low temperatures its susceptibility is relatively appreciable. In order to fit such elements as oxygen, palladium, &c., into a diagram of the same general character as those already given, a *third* type is devised which is shown by Fig. 4.

There is not sufficient space to draw these diagrams to approximate scale or in proper relative proportion to each other.

The elements which are not ferro-magnetic or diamagnetic may belong to the intermediate type.

There may be cases in which an element can pass from one type to another, since by diminishing the negative molecular currents the positive atomic currents may assert themselves and the substance may then become paramagnetic.

Bismuth at 18° C. has a resistivity of 119×10^{-6} and a negative susceptibility of -1.4×10^{-6}. Neglecting the 10^{-6} multiplier, the following equation implies that the negative atomic currents coincide with the joint resistivity representing the magnetic susceptibility in this case:—

$$\frac{-1.38 \times 119}{1.38 + 119} = -1.4,$$

or in the case of copper,—

$$\frac{-0.09 \times 1.78}{-0.09 + 1.78} = -0.094.$$

The coincidence of the negative values on both sides of the equation arises of necessity from the relatively low negative magnitudes, and in itself it is not significant, but when large values are arbitrarily substituted the coincidence ceases, thus in a suggestive way reconciling the prescribed values of the negative susceptibilities with the principle of equality implied by the equation, a limit being thus set. No element therefore could have a resistivity of, say, 10×10^{-6} together with a negative susceptibility of -10×10^{-6}, to take an extreme example.

It should be observed that the magnitudes chosen are not commensurate with each other, but they will serve to illustrate the compound effect involved.

The terms *atomic* or *molecular currents* and *resistivity* are used in a generalised sense, or by way of analogy, and these expressions must not be interpreted too literally, *e.g.*, molecular currents may stand for a resultant effect involving the orientations of electronic orbits but governed by molecular conditions.

The following quotations (1) from *Science Abstracts* (1916, A, p. 168) and (2) from "Recent Physical Research," by Dr. Owen, may be of interest to note:—

1. "*Electron Theory of Paramagnetism*, J. Kroo (*Deutsch. Phys. Gesell. Verh.*, December 30, 1915, xxiv., [17], 452).—Starting with Born and Karman's space-lattice theory the author obtains an expression for the magnetic moment, and on applying the Lorentz-Wien theory of collisions for the specific susceptibility. The results on this theory for Pd and Pt are then compared with those obtained by Onnes and Oosterhuis. It is considered that the theory correctly explains the general behaviour in a qualitative sense although it is only a first attempt. A relation between resistivity and susceptibility would appear to be revealed by this theory."

2. "*Langevin's Theory*. Ampère's molecular current in a circuit of zero resistance is realised in the electronic orbit. A single molecule contains as many elementary current circuits as there are electrons in motion. If these are so arranged that the resultant magnetic moment is nil, we have the *diamagnetic* molecule. When the resulting magnetic moment is finite we may have two cases:—First, when the mutual magnetic influence of these molecules is inappreciable the body is then *paramagnetic*; second, when each molecule is sensibly influenced by its neighbours this constitutes the *ferromagnetic* state. In accordance with Curie's analogy, Langevin treats the first two classes of bodies as consisting of molecules, as it were, in gaseous condition. If the body is diamagnetic no orienting action of the external magnetic field will result, and there will be no change of the aggregate motion. The ulterior encounters between the molecules will take place as before, and no change of temperature can result. Conversely, no change of temperature will modify the diamagnetic property of the body."

Space will not permit quoting to the end of the chapter, which finishes on page 61, in which the *magneton theory* of P. Weiss is given in brief and the notion of *corresponding magnetic states* is discussed. Other parts of the book bear upon the same subject, and these should be read.

In conclusion, the reader should understand that the treatment of the phenomenon of susceptibility as a compound effect involving the analogy of resistance phenomenon is somewhat novel, and while it is easy to raise points unverified as yet by experiment, the elasticity of the method is the main reason for venturing to suggest its utility in co-ordinating the complex phenomena in question. Moreover, referring to Fig. 1, it will be seen that where the curve is steep changes in molecular states would profoundly modify the susceptibility, as is the case with regard to iron, as its susceptibility varies with the magnetising force.

NITROGEN AND ITS COMPOUNDS.*

By HORACE FREEMAN, Niagara Falls, Ont.

(Concluded from p. 207).

Manufacture of Cyanamide.

THE raw materials used in the manufacture of cyanamide are the atmosphere, lime, and coke, and to bring them into the proper combination a plentiful supply of electric power is required.

Calcium carbide is first prepared from the lime and coke in electric furnaces, and is then made to combine with nitrogen from the atmosphere in electric ovens.

Moissan first prepared calcium carbide in Paris in 1892, but though he made many attempts to effect the combination of his product with nitrogen, he was unsuccessful. The carbide which Moissan prepared in his laboratory was chemically pure or nearly so, and it was later shown by Frank and Caro in Germany that only technica

* From the *Canadian Chemical Journal*, ii., No. 5.

carbide containing over 5 per cent or so of lime and other impurities was capable of absorbing the cyanamide industry, and the manner in which this apparently simple invention was financed and supported in Germany is an outstanding example for us to take heed of.

The manufacture of calcium carbide was brought to commercial possibility at Niagara Falls, New York, very soon after the discovery of Moissan, and it was quickly developed in Europe as a consequence wherever cheap electric power was to be obtained. The production of carbide soon became so great that many of the plants were forced temporarily to close, owing to glutting of the market. The invention of cyanamide was their ultimate salvation.

Calcium carbide is manufactured in large electric furnaces into the top of which hang large blocks of carbon about 6 feet long. The lower ends of these electrodes dip into the centre of the furnace, which is filled with a mixture of coke and lime, continually shovelled in at the top. Electric current passes between the ends of the electrodes and through the mixture, which is heated by this means until the lime melts to a liquid, and then undergoes a chemical reaction with the coke, the result being calcium carbide, which collects in a pool in the furnace, and is periodically tapped out into heavy iron chill cars, wherein it is allowed to cool.

Before the carbide is in shape to combine with nitrogen it is crushed and ground to a fine powder. Next it is placed in large perforated steel cans, and these cans are set each inside a separate gas-tight oven constructed of firebrick. A thin rod of carbon passes through the centre of the oven and through the central axis of the can. The passage of an electric current through the pencil heats it to a high temperature, and so transfers heat to the carbide immediately surrounding the pencil. A constant supply of nitrogen gas is fed into the oven and is rapidly absorbed by the hot carbide. The chemical reaction which takes place evolves sufficient heat to heat the next communicating layer of the carbide to the reaction temperature, and so the process repeats itself until the whole contents of the can are red-hot. The nitrogen gas supply is continued until the contents of the can are sufficiently nitrified.

The most important ingredient of this process, the nitrogen, is obtained from the atmosphere. The air is drawn in through pipes some distance from the plant in order to have it free from dust. It is compressed at about 500 pounds to the square inch, and then by sudden expansion is automatically cooled to about 380° below zero, at which temperature it turns to a liquid. This liquid air is then allowed to undergo a process similar to distillation, by which means the nitrogen boils off and is conducted to the fixation ovens containing the carbide. 75 per cent of the liquid air is nitrogen and 25 per cent is oxygen. The oxygen is all left behind in this fractionation process.

The product from the fixation ovens is in the form of a solid black mass, and is called lime nitrogen. It contains more than 20 per cent of nitrogen, but is not yet ready for the market as a fertiliser ingredient. To make it suitable for this purpose it is crushed and ground to a fine powder and is hydrated by admixture with a small quantity of water. This converts the carbide and quicklime remaining in the lime nitrogen into hydrated lime. One or 2 per cent of mineral oil is also added to render the product less dusty, and it is now in shape for shipment under the trade name of "Cyanamid." It is a grey-black powder, and may be used directly on the land, but usually is purchased by the compound fertiliser manufacturers, who mix it with substances containing the two next important plant foods—potash and phosphoric acid.

Some of the Derivatives of Cyanamide and their Uses.

Up to the beginning of the war the cyanamide produced in this country was nearly all sold for its prime purposes as a plant food, but the demand for nitrogen compounds in various highly important industries which bear directly upon war requirements has created a demand for its use in the preparation of a variety of interesting substances.

Ammonia.

Cyanamide readily yields all of its nitrogen content in the form of ammonia by treatment with steam under pressure. Ammonia is easily converted in turn into the majority of other useful compounds containing nitrogen.

Ammonia is used in so many ways in the chemical and allied industries that it would be almost impossible to enumerate them, but it is most widely known for its value for purposes of refrigeration.

"Ammo-phos."

The ammonia produced from cyanamide is largely converted into a substance called "ammo-phos," by absorbing it in a solution of crude phosphoric acid, the phosphate rock of Florida being the source of raw material for the purpose. "Ammo-phos" has the advantage that it carries within itself two of the most necessary plant foods, containing as it does 13 to 20 per cent of ammonia and from 20 to 47 per cent of phosphoric acid in forms which are easily soluble and readily available to the plant. Moreover, the proportions of the ingredients in "ammo-phos" may be regulated for any desired mixture, and the nature of the material is such that it is entirely without those objections appertaining to the usual run of fertilisers, may be kept indefinitely without loss of values, and may be mixed with any other combination of plant foods desired by the fertiliser manufacturer.

"Ammo-phos," on account of its concentrated nature, is able to replace many other forms of mixed fertiliser, and for this reason it may well be claimed that its manufacture will be one of the great advances made to solve the important problem of increasing food production. It is manufactured by the Cyanamide Company at a plant in New Jersey.

Ammonium Sulphate.

Next in importance as a product of cyanamide is ammonium sulphate. This substance, which is used in enormous quantities as a fertiliser ingredient, is manufactured by absorbing the ammonia gas from cyanamide in sulphuric acid. The ammonium sulphate is crystallised in the form of a white crystalline compound from the resulting solution, and contains over 25 per cent of ammonia. Its manufacture is also carried out at the New Jersey plant from the cyanamide produced at Niagara Falls.

Ammonium Nitrate.

By absorbing the ammonia gas in nitric acid ammonium nitrate is formed. This substance is now in great demand by the explosives industries and is the basis of the explosive "ammonal," which is a mixture of ammonium nitrate and aluminium powder. Ammonium nitrate is also mixed with T.N.T., and is so used in high explosive shells.

Nitric Acid.

The nitric acid required for the manufacture of ammonium nitrate is at the present time the most important compound which may be produced from the nitrogen of the atmosphere, for it enters into the composition of all military explosives, which could not be manufactured without it.

The manufacture of nitric acid from cyanamide has been successfully developed to a manufacturing scale and has become of great importance since 1914, as it provides an alternative from the Chilean nitrate source of supply, and has been made use of by Germany on a large scale.

For the production of nitric acid from ammonia the ammonia gas is mixed with air in suitable proportion and the mixture of gases is led over a catalyser at a dull red heat. By the action of the catalyser the ammonia is oxidised, and the gases issuing from the chambers wherein the process is carried out contain oxides of nitrogen, which when dissolved in water form nitric acid. The nitric acid

solution may be concentrated and sold for a multitude of purposes, or it may be used directly in connection with the ammonia plant for the production of ammonium nitrate with high efficiency.

Most people have heard of T.N.T. since the outbreak of the war. It is the most widely used explosive on the battle fronts. T.N.T. is made from toluene, a substance very similar to benzine and obtained with benzine in the purifying of coal-gas. The toluene is mixed with nitric acid in three separate treatments, and a substance called tri-nitro-toluene is the result under certain conditions used in the process for this purpose.

T.N.T., as it is familiarly called, is usually orange coloured and somewhat resembles wax, and, like wax, may be easily melted. Shells are filled with safety by melting it over steam and pouring it into the upturned shells, which are left to cool until the contents are solid. T.N.T. is inflammable, but not explosive until detonated in a confined space. It cannot be made without nitric acid.

Detonators for air explosives contain fulminate, a highly dangerous substance which explodes on percussion and which also requires nitric acid for its manufacture. For the manufacture of fulminate, mercury is dissolved in nitric acid and the solution is poured into alcohol at a temperature of 55° C. The product is a greyish white precipitate, which must be washed and stored under water. Silver may be used in place of mercury for this manufacture, but the product is even more dangerous to handle. The percussion caps of shells or cartridges contain fulminate. A slight blow on the cap suffices to explode the fulminate which in turn fires the high explosive contained in the shell.

Cyanide.

Case hardening compounds play an important part in the munitions industries. A mixture of cyanamide and salt when heated produces cyanide and makes an excellent case hardening-compound, which is cheaper than other substances used for the purpose.

The manufacture of cyanide for gold and silver extraction is an important development of cyanamide. Cyanide was largely produced in Germany at the outbreak of war, and that country had a practical monopoly of the cyanide trade. The cyanide produced there, however, was not made from cyanamide or atmospheric nitrogen, but from ammonia and metallic sodium under the invention of Hamilton Y. Castner, whose name is well known for other important industrial developments at Niagara Falls. The process of Castner is expensive for a chemical in such great demand as cyanide, and many attempts have been made to find cheaper means of production, and it was in the search to this end that Frank and Caro discovered cyanamide.

The blockade of Germany has cut off a large amount of the cyanide supply to this great mining country, and the natural result has been to revive attention to means of securing cyanide from cyanamide.

It has now been found that cyanamide will yield its nitrogen all in the form of cyanide by fusing the cyanamide with salt at a high temperature, and the crude cyanide obtained is used successfully without purification for the extraction of gold and silver from ores.

This process of producing cyanide also has been developed first to a large manufacturing scale at Niagara Falls, and its product has already been used in the extraction of large quantities of the precious metals.

For the purpose of gold and silver extraction a very weak solution of cyanide is agitated with the finely crushed ore. The gold and silver are dissolved by the action of the cyanide, and the filtered solution containing these metals is treated with finely-divided zinc, whereby the precious metals are deposited in the form of a black sludge. This is melted and yields bars of base bullion which are sent to the refinery.

The use of cyanide for case-hardening purposes has been referred to. Its third important use is an insecticide, and large quantities are used in orchards, greenhouses, and government inspection stations where incoming nursery stocks are examined and treated. The cyanide for this use is sometimes sold in small zinc cartridges or containers. A cartridge is dropped into a dish of sulphuric acid placed in the greenhouse or tent erected over the tree or plants under treatment. The acid attacks the zinc, dissolving it away, and next acts upon the cyanide, producing prussic acid which is instantly fatal to all living things.

Vast amounts of prussic acid made from cyanide are now used on the battle fronts. It is a colourless gas at the ordinary temperature, lighter than air, but instantly fatal unless very much diluted with the atmosphere. Where it is not fatal the after effects of this gas are not nearly so terrible as those of chlorine. It is possible that future developments in this direction might produce a gas either extremely quick and painless in its action or without after effects in case a complete fatal dose had not been inhaled. There is no doubt that Germany's great stocks of cyanide which she had not been able to export are being used in the preparation of prussic acid for use at the front.

Dicyandiamide.

Another development of cyanamide that has been brought into practice here is dicyandiamide, a white crystalline substance used in the preparation of dyes and as a deterrent or retarder in explosives. It is prepared by extracting cyanamide with hot water and recrystallising the dissolved dicyandiamide from the resulting solution. Its effect in mixtures with explosives is to reduce the temperature of explosion and so serve to increase the life of the gun barrel.

A number of organic compounds have been produced in the laboratory from cyanamide, for which no great commercial uses have yet been developed, and consequently methods of manufacturing practice have not been worked out. It will readily be conceded that cyanamide is the most useful and remarkable nitrogen compound available to our use, and its development in our midst is a matter of the highest importance to our welfare. The world is producing over one million tons of cyanamide each year, and of this Germany is manufacturing more than six hundred thousand tons containing approximately one hundred and twenty thousand tons of nitrogen taken from the atmosphere. The greater portion of this fixed nitrogen is used by Germany on the battle line in the form of high explosives; the remainder she uses at home to increase the food production of the country.

THE CHROME-TANNING INDUSTRY.

Tanning by means of chromium compounds has been very much more extensively developed in Germany and the United States of America than in this country. German and American manufacturers quickly realised the value of the new method, and made such rapid progress in the practice of the various processes that they were able to sell in the United Kingdom at prices lower than the British cost of production, and by this means to discourage the establishment of the industry here.

There was at that time no prejudice against using foreign goods at the expense of British manufacturers, and, since foreign chrome tanned leather possessed certain obvious advantages, British boot manufacturers were ready to purchase it. It was unfortunate that the chrome process was not developed in the United Kingdom, because there is no doubt that it had become a serious factor in the deflection of tannage of certain hides and skins from this country to our competitors in Germany and the United States of America. This movement of trade is most pronounced in respect of the hides and skins exported from India.

Indian Hides and Skins.

Before the war India exported 345,000 cwt. of raw hides, of which the Central Empires took one half, the United States of America one-third, and the remainder was divided between the United Kingdom, the Netherlands, and Italy. The position regarding raw goat and sheep skins was just as unsatisfactory to this country. The United States of America imported direct about 75 per cent of the total export of raw goat skins of India, the United Kingdom 10 per cent, France 7 per cent, the Netherlands and Belgium 5 per cent, and Germany an insignificant quantity. The American import of goat skins is turned into glacé kid, and a considerable proportion of the American production of glacé kid is taken by the United Kingdom. America, moreover, took 87 per cent of the Indian export of raw sheep skins.

The situation appears in no happier light when an examination is made of the Indian export figures during the last half century. The monopoly in the export trade in Indian raw ox and cow hides, which this country enjoyed half a century ago, had steadily fallen away until practically the whole of the trade had passed at the time of the outbreak of war into German hands for German tanning. It is probably not a coincidence merely that the capture of the export trade in Indian raw hides by the German tanners commenced with the appearance of the first commercially successful process of chrome-tannage, and that it passed steadily into German hands with the development of the chrome process. It would therefore appear that the change was not unconnected with the commercial development of the new tanning process in Germany.

Effect of the War.

The position was not felt acutely here until the outbreak of war convulsed the world's markets, and made its effect felt in the raw-hide trades. The sudden demand for footwear for the armies of this country and her Allies made it essential that the normal tanning capacity of this country should be materially extended. At the same time fresh sources of raw materials had to be utilised, and once more attention was directed to the vast potentialities of the Indian Empire.

Concurrently with the development of chrome-tannage in Germany and the deflection to that country of the raw-hide exports of India there developed an intimate connection between the German Tanning Associations and the hide firms in the Indian market at Calcutta. The connection of the Calcutta firms with their German customers was the result of mutual business interests, and the tendency, once developed, was furthered by the activity of the German associations, who proceeded to Germanise the direction and management of the Indian hide firms. Their efforts were aided by the systematic support of the German Government and German steamship companies.

The German influence in the "Calcutta ring" has already been dealt with in such a manner as to remove its obstruction to the free flow of the export of hides to markets outside of the Central Empires. The tanners of the United Kingdom on their part have risen to the occasion, and met the war-time need of this country and its Allies by a modification and extension of their businesses to supply the war-time requirements of the Allied armies. But it is not to be assumed that the changes that have been inaugurated and developed up till now will in themselves suffice to maintain the present connection of the United Kingdom tanners with the trade in exports of hides from India.

Attitude of the Tanning Industry.

Already various proposals for Government intervention and support have received the very active consideration of the tanning industry both here and in India. The question of the composition of the personnel of firms in the Indian trade has had very serious attention, and the question of fiscal policy in respect of export duties has been approached from more than one point of view by the tanning industry of India and the United Kingdom. It has been approached by the United Kingdom tanning industry and a section of the Indian tanning industry with the wide object of developing the tanning of Indian kips within the British Empire, and by another section of the Indian tanning industry with the narrow object of developing the tanning of these kips exclusively within the borders of British India. Whatever may be the outcome of these various fiscal proposals, there is no doubt another problem that will have to be faced by the tanning industry if it desires that this trade shall not return into German hands. That problem is how to produce the same material from these hides which Germany has proved to be in demand. The chrome-tanning of the hides will have to be studied and developed to an adequate extent in this country.

Vegetable v. Chrome Tanning.

Up to the present the tanners of the United Kingdom have shown a distinct, even an overwhelming, preference for vegetable tannage as distinguished from mineral, including chrome tannage. The fundamental principle in both vegetable and mineral tanning is the same; it may be thus expressed in the words of a distinguished tanning authority:—"It is not only necessary to dry the fibres in a separate and non-adhesive condition, but so as to coat them or alter their chemical character that they are no longer capable of being swelled or rendered sticky by water." In vegetable tannages the astringent tannins in colloidal solution are absorbed by the hide fibres, and cause the contraction and separation of the fibres which is the first requisite for leather production. The colloids thus precipitated undergo some change—it may be polymerisation, dehydration, or oxidation—which, at any rate, is irreversible and give rise to a product which will not swell or dissolve in water.

In chrome tannage there is utilised a compound which, like the aluminium, ferric, and manganese compounds, is capable of producing colloids. The colloidal basic salt in the chrome tannage is capable of slow absorption by hides immersed therein with the result defined above as fundamental to a tanning process.

Chrome-tanning Processes.

The action of chromium salts, whether normal or basic, on hides was first studied by Knapp ("Die Natur und Wesen der Gerberei," 1858). Knapp described a method of chrome-tanning which is identical with one of the modern processes, for he proposed the formation of a basic chromium salt by the addition of some compound, such as normal sodium carbonate, to the chrome solution after the manner of the so-called "single-bath" process. In 1878, Heinzerling patented a process for making chrome leather in which skins were treated with alum and bichromate of potash, the latter being reduced at the expense of the hide fibre and the fats employed in currying. The process, however, was not a commercial success. In 1881 Eitner obtained an Austrian patent for a combined chrome and fat tannage, in which he recommended the use of the normal basic salt $Cr_2(OH)SO_4$, obtained by adding soda to chrome alum in solution; but he, too, failed to produce a successful commercial article. In 1884 a successful two-bath process was patented in the United States of America by August Schultz, and the process proved a commercial success in the production of light leathers. According to the Schultz process the skins are impregnated with a solution of potassium bichromate, acidified with hydrochloric acid, and the chromic acid absorbed by the skins is subsequently reduced by means of sulphurous acid, through the immersion of skins in an acidified solution of sodium thiosulphate.

The chemical actions involved in the Schultz process may probably be divided into two stages. In the first stage the chromic acid absorbed by the skins in the first bath reacts with the acidified sodium thiosulphate of the second bath to produce a colloidal basic chromium compound having the composition $Cr_2O_3CrO_3H_2O$ and sodium tetrathionate $Na_2S_4O_6$. The brown colour of the skins during this process probably marks this particular stage. The clearing or brightening of this colour with the development of a pale bluish tint is probably due to the further action of the hydrochloric acid, resulting in the production of chromium chloride and the precipitation of colloidal sulphur from the tetrathionate of soda. In hot solution the basic chromium compound passes into chromium oxide, Cr_2O_3. The free sulphur produced in the leather by this process adds to its softness, and gives it a better colour than is obtained by the single-bath process. On the whole the two-bath process is the more suitable for light leathers; it is unsuitable, however, for leather that is to be japanned.

The popularity of the single-bath process is its simplicity of control. Various mixtures have been placed on the market from time to time, and besides the soda and chrome alum mixture there is, among others, the mixture produced by Prof. Procter in 1897, consisting of sugar (cane or glucose) and bichromate with a limited quantity of hydrochloric acid.

Advantage of Chrome Tanning.

One of the main advantages of chrome tanning is rapidity of the process as compared with vegetable tannnage, and the consequent increase in the possible turnover. The waterproofness and compactness of the leather after fat liquoring, &c., causes it to be sought after for box-calf, glacé kid, and other upper-leathers. Its superiority in tensile strength over vegetable-tanned leather makes it peculiarly adapted for picking bands, belt and strap leathers. The affinity for chrome tannage varies from leather to leather. Sheep-skins, horse-hides, and kips show a smaller affinity for it than goat-skins, ox-hides, and especially calf-skins. The basicity of the single chrome bath should therefore be modified to suit the skins to be tanned, and various mixtures are supplied to the trade with that end in view. The further property of the chromium salts of forming lakes with many mordant colouring matters makes the use for tanning skins of considerable interest where the production of coloured leathers is the object in view. The chrome tannage of skins entails closer technical supervision of processes then vegetable tannage; but the problems it offers the chemist and tanner and the possibilities it affords of achieving all those results in leather production that have given the German and American tanners their advantages in the past, must necessarily appeal to progressive tanners and leather chemists of this country.—*Board of Trade Journal*, May 9, 1918.

FERTILISING INDUSTRY CONFERENCE.

A Conference fully representative of the Fertilising Industry was held at the Ministry of Reconstruction on Friday, June 21, for the purpose of discussing the formation of an Interim Industrial Reconstruction Committee for the industry. These Committees, as has been explained in these columns in previous issues, are a kind of halfway house to the permanent Joint Standing Industrial Councils which were advocated by the Whitley Committee. They will assume temporarily the functions of the permanent Industrial Councils for dealing with all problems of the reconstruction period, after which it is hoped they will be in a position to convert themselves into permanent Industrial Councils.

Mr. J. Wilson Hope, C.B.E., of the Ministry of Reconstruction, was in the Chair, and the following representatives of the trade were present:—

Messrs. H. Bamford, Walter Packard, R. Waterfall, L. E. Strong, T. H. Rawson, C. J. Williams, Alex. Darling. (The Fertiliser Manufacturers' Association).

Messrs. E. Castehwin and F. W. Speyer. (Sulphate of Ammonia Association).

Mr. John Main. (Anglo-American Association).

Messrs. A. Whiting, J. Jones, Jas. McVay. (National Federation of General Workers).

Mrs. E. Calthrop. (National Federation of Women Workers).

Major G. D. Hazzledine. (Board of Trade).

Mr. Bertram Wilson. (Ministry of Labour).

After the Chairman had stated the purpose of the meeting, Mr. Bertram Wilson, of the Ministry of Labour, said it was the work of that Ministry to set up Joint Industrial Councils which, when established, would give complete self-government to each industry. These permanent committees, however, took some time to establish, and in many trades it had been found advisable to start with an Interim Reconstruction Committee, from which beginning a Joint Standing Industrial Council could easily develop.

Major Hazzledine, of the Board of Trade, urged the desirability of regular consultation between the employers and employees in each trade with regard to different trade problems, and the advisability of a regular exchange of view between the two sides as to the outlook and difficulties of each.

In the course of a general discussion which followed, Mr. Packard said that the members of the Fertilisers and Manufacturers' Association were quite in sympathy with the object of the meeting, but could not yet nominate representatives to serve on the Committee should one be set up. He expressed the hope that the trade union representatives on the Committee would be men thoroughly conversant with the trade. He asked also whether the supply of imported raw material was to be bound up with these committees, and whether in trades where no such committees were set up raw materials would not be forthcoming.

The Chairman, in reply, said that it was not necessary to appoint representatives at once. With regard to raw material he said that, though there was no idea of connecting these Committees with the supply of such, yet it was only logical to conclude that the claims of a whole trade thoroughly organised when expressed through a representative body would carry more weight than those of an individual firm.

Mr. Jones, of the National Federation of General Workers, said that his Union would certainly see that the men elected to serve on the Committee were men thoroughly conversant with the trade.

Some discussion arose as to the representation of associations, such as those of the fish meal, fish guano, and sulphate of ammonia manufacturing trades. The Chairman suggested the formation of a composite committee which would include all branches of the industry, explaining that sub-committees could be appointed should they be found necessary.

Mr. Packard then moved, and Mr. Jones seconded, a resolution forming an Interim Industrial Reconstruction Committee for the whole Industry. After a discussion as to the representation of the different districts in which the trade is carrying on it was decided that the Committee should consist of twelve representatives of employers' associations and twelve representatives of trade unions.

The first meeting of the new Committee is to be held at the Ministry of Reconstruction, 2, Queen Anne's Gate Buildings, Westminster, at 11 a.m., on Friday, July 19, 1918.

VAN'T HOFF FUND.

In agreement with the regulations of the Van't Hoff Fund, founded on June 28, 1913, persons interested are informed herewith of the following particulars :—

The foundation, situated in Amsterdam, and of which *the supervision is vested in the Royal Academy of Sciences* there, is appropriated to give from the rents of the fund every year, before March 1, endowments to investigators in the field of pure and applied chemistry who will have applied for such an endowment to the Committee charged with considering the applications and awarding the grants.

This Committee is at present constituted as follows:— A. F. Holleman, President; S. Hoogewerff; A. Smits; E. H. Buchner, Secretary. If desirable this Committee may appoint still other members for one year only, to co-operate in judging of the applications made.

The names of persons to whom a grant is allowed will be published. The grantees are requested to send to the Committee some copies of the papers relating to the results of their work; but for the rest they are at liberty to choose the manner of publication, as well as the journal, in which to publish their results, if only they mention the fact that the research was made with an endowment from the Van't Hoff Fund.

The amount available over 1919 is about one hundred and fifty pounds.

Applications should be sent, registered by post, to *Het bestuur der Koninklyke Akademie van Wetenschappen*, bestemd voor de Commissie van het Van't Hoff Fonds, *Trippenhuis, Kloveniersburgwal, te Amsterdam*, with a detailed account of the proposed use of the grant (the amount whereof has to be expressly mentioned), and of the reasons on which the candidates ground their claim. They must be received before November 1, 1918.

(In the name of the Committee),

A. F. Holleman, President.
E. H. Büchner, Secretary.

Amsterdam, May, 1918.

CROPS CONDITIONS ON THE FIRST OF MAY, 1918.

The difficulty of obtaining their food supplies, experienced in the principal countries of Europe during the season 1917-18, has induced the Governments concerned to guard against the occurrence of similar difficulties in the ensuing season, by an increase of national production. How far has this aim been realised? It is too early to give an accurate forecast, but we are able to deal with two factors that allow us to form some idea as to what we have the right to expect from the agricultural production of 1918. These two factors include the extent of the areas sown and the condition of the crops on May 1 after the final disappearance of winter.

The May *Bulletin of Agricultural and Commercial Statistics* published by the International Institute of Agriculture in Rome supplies interesting data on both these points of view. With regard to the areas sown for the season 1917-18 in the northern hemisphere, we find that of all the countries where definite figures are available, Denmark, France, Great Britain, Luxemburg, United States, British India, Japan, Tunis, indicate areas sown with wheat this year decidedly larger than those of the previous agricultural season. For the United States and for British India, in particular, the increase of winter sowings is about 5 per cent.

Only in Spain and Canada have the sowings decreased, but very slightly (less than 2 per cent) in Spain, though 13 per cent in Canada. *We must remember that we are* dealing for Canada for winter wheat only, and that generally this description is no more than one-tenth of the total crop.

What was the condition of these crops on May 1 last? *Here also there is reason for satisfaction.*

The information furnished by the *Bulletin of Agricultural and Commercial Statistics* allows it to be stated that the condition of crops at that date was very good in Ireland, good in Spain, Great Britain, France, Morocco, and Tunis. The same may be said as regards the spring sowing in Canada, which, as we have seen, is much the most important crop in that country. Crop prospects were average ones in Italy, Switzerland, the United States, and Egypt, and the position was a bad one only for the winter wheat crop of Canada.

In the United States, the Bureau of Crop Estimates, taking as a basis the condition of the winter wheat and rye crops in April 1 last and the areas under these two cereals, estimates that, if circumstances are normal from that date till harvest time, the farmers of that country will reap 152·410 thousands of quintals of winter wheat and 21·845 thousands of quintals of rye. The crop in 1917 was 113·782 thousands for the first named and 15·277 thousand of quintals for the latter.

To sum up, we are enabled to state that both on account of the increase in areas sown, and of the decidedly *favourable condition of the crops on May 1*, we have the right to expect in the coming summer a better crop of food grain than that in 1917.—*International Institute of Agriculture*, Rome, May 23, 1918.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, May 30, 1918.

Sir J. J. Thomson, O.M., President, in the Chair.

Papers were read as follows :—

"*Method of Avoiding Collision at Sea.*" By Prof. J. Joly, F.R.S.

The method of avoiding collision at sea now proposed involves the determination of distance between ship and ship at regulated intervals by means of synchronised signals (preferably wireless and submarine).

The principle involved is that ships which are advancing so as to collide approach one another with constant velocity; *i.e., the relative velocity is constant. If they* are going to pass clear the relative velocity is not constant, diminishing to nothing when the vessels are at the passing distance and then changing sign.

The paper embodies tables and curves showing the variations of relative velocity for different passing distances. Assuming that a quarter of a sea mile is distinguishable by the use of synchronised signals the method appears to be certainly available for a passing distance of half a mile.

Mechanical aids towards increasing the reliability of observations and facilitating them are described.

The advantages of the method are chiefly that it involves no special intercommunication between ship and ship (other than the regulated synchronised signal supposed to be emitted by all vessels navigating in fog or thick weather), and that the distance separating the vessels is necessarily kept under observation throughout.

"*Statistical Survey of Colour Vision.*" By R. A. Houstoun, D.Sc.

The colour vision of 79 students was tested by the method of Dr. Edridge-Green's colour-perception spectrometer. Three of the 79 were found to be colour-blind.

The number of observers containing a given number of patches was plotted against the latter, and a frequency-curve obtained. If the Young-Helmholtz theory is true, this curve should have two maxima, one for normal colour vision and one for dichromatism. The results show,

however, that normal colour vision has quite enough "scatter" to explain colour blindness as an outlying portion of itself, and that it is not necessary to assume the existence of a separate maximum.

Various points of interest in connection with the observations are discussed, and it is suggested that a more extensive survey made on similar lines at different places might settle definitely once for all the vexed question of colour-vision theory.

"Production of Anthocyanins and Anthocyanidins." (Part III.). By A. E. EVEREST, D.Sc.

The paper is a continuation of the author's previous work, and deals with the mode of formation, in Nature, of the anthocyanin pigments.

Available data concerning the co-existence of anthocyans and flavonol derivatives are discussed, and preliminary experiments with a view to the elucidation of the manner in which the anthocyanin pigments are formed in plants are described.

For the first time direct chemical evidence is recorded which supports the prevailing view that the anthocyanin pigments are produced in Nature *via* flavonol derivatives, it being shown, with a very considerable degree of certainty, that in the flowers examined (purple-black Viola) the anthocyanin pigment exists side by side with a glucoside of the flavonol derivative, from which the anthocyan would be produced by reduction.

The isolation from the purple-black Viola (Sutton's "Black Knight") of a pigment identical with Willstätter's Violanin, and experiments to show the presence of a myricetin glucoside in the same flower, are described.

CHEMICAL SOCIETY.

Ordinary Meeting, May 2, 1918.

Prof. W. J. POPE, C.B.E., F.R.S., President, in the Chair.

THE PRESIDENT announced that the Society has lost, through death, the following Fellows:—William Henry Blake and Herbert William Mills Willett.

Mr. A. W. Willis was formally admitted a Fellow of the Chemical Society.

Certificates for election were read for the first time in favour of William Baird, 16, Kinnoull Mansions, Clapton, E. 5; George Rowland Bolsover, Assoc.Met., 31, Rossington Road, Brocco Bank, Sheffield; John William Cobb, East Garth, Lower Wortley, Leeds; George William Dunster, 43, Wards Road, Seven Kings, Ilford; Stanley Elliott, B.Sc., 40, Arundel Gardens, W. 11; Robert Ellison, 19, Longdin Street, Latchford, Warrington; Frank Scott Fowweather, M.Sc., 62, Dale Street, Liverpool; Stanley Joseph Green, B.A., Lieut. R.N.V.R., Royal Naval Air Station, Stratford, E. 15; Francis John McConnell, Anti-Gas Department, University College, Gower Street, W.C. 1.

Messrs. A. J. Chapman and P. Edgerton were elected Scrutators, and a ballot for the election of Fellows was held. The following were subsequently declared duly elected as Fellows:—George Edwin Anderson, B.Sc.; Thomas Thompson Best, Ph.D.; Rudolf Isaac Blackburn, B.A., B.Sc.; James Booth; Cyril Bride, B.A., B.Sc.; Wilfrid John Brizell; Giuseppe Bruni; Colin Campbell, M.Sc.; Albert Henry Clark, Ph.G., B.Sc.; John George Clarke, M.A.; Govinda Chandra Das, B.Sc.; James Scott Dick, B.Sc.; Stanley Dixon, M.Sc.; Frederick Charles Duggleby; Francis John Dymond, B.Sc.; Owen Charles Edwards, B.Sc.; Horace George Evans, B.A., B.Sc.; John Henry Freeman; Charles Eddie Gallagher; Arthur Geake, M.Sc.; Archibald Edwin Goddard, B.Sc.; Thomas Greetham; William Jay Hale; Robert John Hughes, B.Sc.; William Hughes; Henry Francis Everard Hulton; Stewart Roy Illingworth, B.Sc.; Harold Thomas Islip; George Johnson; Benjamin Llewellyn, M.Sc.; Nathaniel Makover, B.Sc.; Robert Duncan Masson; William Alexander Montagu; George Turpin Moore, B.Sc.; George Newbery, B.Sc.; William Charles Peck; Harold Scragg; Harry Singer; Arthur Nutter Smith; Maurice Smith; David Dryden Spence; John Henry Taylor; Stephen Veitch Telfer, M.B., Ch.B.; Alexander Lyle Thomson; Thomas Tucker; Augustus James Tyrrell; William Edwin Upton, M.A.; Walter Arthur Voss; Thomas Wallace, M.Sc.; Stanley Warburton; Arthur Robert Warnes; Herbert John Watson; Harry William Webb, M.Sc.; James Wood, M.A., B.Sc.; Henry Worth.

The following paper was read:—

"Spinacene, and some of its Derivatives." By A. CHASTON CHAPMAN.

Ordinary Meeting, May 16, 1918.

Prof. W. J. POPE, C.B.E., F.R.S., President, in the Chair.

The PRESIDENT referred to the loss sustained by the Society, through death, of the following Fellows:— Thomas Watson Lovibond and Sir Alexander Pedler.

It was announced that the Council had decided to reprint the President's Address and to circulate it among Members of the Houses of Parliament, Educational Authorities, and others holding public appointments. The Council, wishing to enlist the aid of Fellows in the circulation of the Address, have decided to provide copies which can be obtained by Fellows free of charge on applying to the Assistant Secretary.

Messrs. H. Singer, C. E. Gallagher, and W. A. Voss were formally admitted as Fellows of the Chemical Society.

Certificates were read for the first time in favour of Joseph Gauld Bearn, M.Sc., Farnborough, Hants; Roland Lebeg Townley Clarkson, 1, Lebanon Road, Wandsworth, S.W. 18; Thomas William Derrington, 20, Alric Avenue, New Malden, Surrey; Sidney Fleminger, 297 Amhurst Road, N. 16; Fred Henesey, B.Sc., 17, Nile Street, Liverpool; John Bright Hoblyn, 106, Tennyson Road, Luton; John Laurence Pitchford Hollingworth, 138, Hither Green Lane, Lewisham, S.E. 13; James Henry Lindfield, 33, Preston Road, Leytonstone, E. 11; Alfred Zygmunt Molteni, 25, Caithness Road, Brook Green, W. 14; Madyar Gopal Rau, M.A., The Presidency College, Madras; Bertram Leonard Read, B.Sc., Cranleigh School, Surrey; Louis Stott, 34, Elmfield Terrace, Savile Park, Halifax; John Turnbull, 18, Wilfred Street, Derby; Richard Henry Vernon, Ph.D., 16, Park Parade, Cambridge.

The Ordinary Scientific Meeting was then adjourned and the Informal Meeting declared open.

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS.

Ordinary Meeting, June 5, 1918.

W. T. BURGESS, Vice-President, in the Chair.

CERTIFICATES were read for the second time in favour of Mr. Edward Chapman and Mr. Herbert Savage, A.I.C.

The following were elected members of the Society:— Mr. Denys Richard Wood, F.I.C., and Capt. Hubert James Llewellyn Parker.

The following papers were read:—

"A Method for the Colorimetric Estimation of Cobalt." By E. GABRIEL JONES, M.Sc., F.I.C.

The method, which is designed particularly for the *analysis of varnishes and zinc paints, is based upon the* reaction of cobalt with the sodium salt of α-nitroso-β naphthol, the effect of several other metals which are likely

to be present being eliminated by the addition of ammonium citrate. In the presence of nickel, copper, or large quantities of manganese, preliminary treatment is necessary for the removal of these metals, satisfactory methods for which are described.

"*The Valenta and Crismer Tests.*" By J. H. JOHNSTON, M.Sc., F.I.C., and ALAN W. STEWART, D.Sc.

The difficulty in obtaining comparable figures in the Valenta test when using glacial acetic acid from different sources has led the authors to prefer the use of the Crismer test. Absolute alcohol has been used as the solvent in the test, as it can be obtained commercially of constant strength. The Crismer numbers of various fats are given. It is shown how the Crismer test, in conjunction with the butyrorefractometer, forms a rapid method of detecting the presence and nature of foreign fat in butters and lards.

"*Nucleic Acid and its Analytical Examination.*" By A. CHASTON CHAPMAN, F.I.C.

The author has worked out a method for the manufacture of plant nucleic acid on a large scale, and at the present time considerable quantities of this acid and its salts are being manufactured for the first time in this country. The more important properties of nucleic acid are described, and a number of methods are given for its chemical examination and evaluation.

"*New Method of Identifying Starches.*" By A. WYNTER BLYTH, M.R.C.S., F.I.C.

The author describes a method of identifying starches by taking careful measurements of the individual grains, and from these measurements compiling graphs, each starch having its own particular graph.

"*Optical Dispersion of Oils and Fats.*" By PERCIVAL J. FRYER, F.I.C., and FRANK E. WESTON, B.Sc.

The authors have made observations of the refractive indices for the C, D, and F lines of the spectrum of most of the commonly occurring fats and oils, and have calculated the dispersive power corresponding to the formula $\left(\frac{n_F - n_C}{n_D - 1}\right)$.

They have investigated the effect of free fatty acidity, oxidation, and polymerisation on the dispersion figure. The effect of the temperature of the observation has also been considered. The instrument used was the Pulfrich refractometer, using a hydrogen vacuum tube of a pressure of about 2 mm. Observations have also been made on the dispersion of selected mineral oils and turpentine.

"*Opium Wax.*" By JITENDRA NATH RAKSHIT.

The paper describes the separation of a wax from opium and the isolation of the unsaponifiable matter from the latter. Some analytical constants and properties of each are given.

"*Estimation of Morphine in Opium by Polarimeter.*" By JITENDRA NATH RAKSHIT.

The author describes a process for the polarimetric estimation of morphine after isolation of the alkaloid from opium as the calcium salt. The results obtained by the method are compared with those obtained by the B.P., 1914, and U.S.P. processes.

"*Two Plant Products from Colombia, S.A.*" By ALFRED LOUIS BACHARACH.

The two products dealt with are the oil of *Jessenia polycarpa* and the seeds of *Caryodendron orinocense*. Descriptions and analyses of each are given, and, for purposes of comparison, the recorded figures for olive oil and walnuts respectively. The analytical values of the oil, obtained by extracting the crushed seeds with ether, are also given.

Royal Society.—The Croonian Lecture, "The Physiological Basis of Thirst," was delivered by Major W. B. Cannon, M.R.C., U.S. Army, on June 6, 1918.

NOTICES OF BOOKS.

Directions for a Practical Course in Chemical Physiology. By W. CRAMER, Ph.D., D.Sc., M.R.C.S., L.R.C.P. Third Edition. London, New York, Bombay, Calcutta, Madras: Longmans, Green, and Co. 1917. Pp. viii+119. Price 3s. net; 4s. net interleaved.

THIS book has for some time been well known and appreciated by teachers and students of physiology, and the third edition may be confidently recommended to the notice of those who are not already acquainted with it. It is not in any sense a text-book of physiological chemistry, but contains very clear and full directions for the performance of the experimental work which should be performed when such a book is being studied. A most useful collection of tests is included, and they are all described so explicity and accurately that the student should be able to get a thoroughly well-founded knowledge of practical physiological chemistry from it. The experiments on the use of the polarimeter, which were included for the first time in the second edition, are particularly instructive and useful, and some practice is also given in spectral analysis. The plan of beginning with the study of familiar substance, such as potato starch, white of egg, milk, &c., has much to recommend it, and provides a good introduction to the more difficult work on the tissues, metabolism, &c., which follows it.

The Treasures of Coal-tar. By ALEXANDER FINDLAY, M.A., D.Sc., F.I.C. London: George Allen and Unwin, Ltd. 1917. Pp. xiii+137. Price 4s. 6d. net.

THE author of this book rightly lays special stress upon the fact that the neglect of science in Great Britain is not to be ascribed to the fault of educationists or manufacturers, or indeed any special class, but to a national defect of character which is slowly being recognised. He quotes the words of the great German industrial chemist to the effect that the English are incapable of the moral effort necessary to remedy that defect and to take up a study which requires patience, concentration, and disinterestedness, and he points out the immense importance of increasing the interest of the nation in scientific subjects. One necessary means to that end is the production of suitable literature, and in this book he discusses in easily intelligible and non-technical language a particularly interesting and valuable group of industries, those dependent upon coal-tar for their raw material. The book gives a historical account of the manufacture of tar, its distillation, and the substances derived from it. The chapter on molecular architecture is a strikingly clear *résumé* of the subject, and the parts on drugs and dyes are also profoundly interesting and enlightening.

Introduction to Inorganic Chemistry. By ALEXANDER SMITH. Third Edition. London: G. Bell and Sons, Ltd. 1918. Pp. xiv+925. Price 8s. 6d. net.

THIS excellent text-book of inorganic chemistry is certainly unsurpassed for the amount of matter it contains, and it is a wonderfully good investment at its comparatively low price. If the first year student at college or technical school means to limit his reading to one book this is the one for him, while even if he possesses others he will find it most valuable for its excellent summaries and its clear expositions of theoretical matters. In the third edition more attention has been paid to the applications of chemistry, and there has been a certain amount of rearrangement. Modern work has been brought under notice, and very useful accounts are given of the work of Moseley on atomic numbers, and Bragg on crystal structure, for example. The sound philosophical basis of the author's work makes his books very stimulating to the more thoughtful students who want to look beyond the

more obvious phenomena of chemistry, and they cannot fail to benefit by the use of a book every page of which requires concentrated attention in reading and provides much food for thought.

Experimental Inorganic Chemistry. By Alexander Smith. Sixth Edition. London: G. Bell and Sons, Ltd. 1918. Pp. vii+171. Price 3s. 6d. net.

This laboratory guide is intended to be used with the author's "General Chemistry fo Colleges or Introduction to Inorganic Chemistry," and provides instructions for performing experiments to illustrate these books. It has been found very useful by teachers as well as students, and it contains a full course of experimental work from which shorter courses could very easily be adapted. The text is so full of questions and references that it would seem practically impossible for the user of the book to do his work heedlessly, or lose sight of the principles involved owing to his absorption in the experimental details, which is not unfrequently the case with beginners in inorganic chemistry. Great stress is laid upon the need for attention to quantitative relations, and the author's contention that the power to reason quantitatively is of inestimable value and may be cultivated by the study of inorganic chemistry is undoubtedly true. Teachers will find that that they can learn a good deal about laboratory organisation and management from the book. It is interleaved throughout, in order that rough notes, records of weighings, &c., may be made by the student in the laboratory.

The Alunite Deposits of Australia and their Utilisation. Published under the authority of the Executive Committee of the Advisory Council of Science and Industry. Melbourne: Albert J. Mullett. 1917.

In this short report of the Special Committee appointed to investigate the Australian deposits of alunite and their suitability for the production of potash, methods of manufacturing potassium sulphate from the mineral are described, and some practical notes on working plants are added, although it is not possible to give details as to cost. The manufacture of alum from the same source is also briefly discussed. An important section of the report deals with the use of roasted alunite as a fertiliser. It has been found that if the substance is heated in a suitable furnace, either with or without carbonaceous material, until all the aluminium sulphate is decomposed, the finely ground product, which is a dry white powder, is slightly more effective than high-grade potassium sulphate or chloride when used in equivalent amounts corresponding to their potash contents. Thus alunite provides an easy means of supplying potash to crops, and it is to be hoped that the fruit crops of Queensland and New South Wales, which are already suffering from a lack of potash, may benefit thereby.

The Relation of some of the Rarer Elements in Soils and Plants. By W. O. Robinson, L. A. Steinkoenig, and C. F. Miller. United States Department of Agriculture, *Bulletin* No. 600.

This Bulletin gives the results of determinations of the presence of some of the rarer elements in plants grown in soils which are known to contain them. The methods adopted in the estimations are described, and the results are summarised and shortly discussed. It was found that very small amounts of lithium, chromium, barium, strontium, titanium, &c., are usually to be detected in the ash of plants if they are present in the soil upon which they have been grown. Vanadium is often absent, and molybdenum was never found. There is no indication that any of these elements need be taken into consideration in preparing fertilisers.

CORRESPONDENCE.

STEEL ANALYSIS.

To the Editor of the Chemical News.

Sir,—I think that the following list gives a fairly complete summary of the books on "Iron and Steel Analysis" published in the last few years, and should suffice for your correspondent of June 21.

There are three classics which must find a place in every metallurgical laboratory, and of which new editions appear more or less frequently.

1. "The Analysis of Iron," Blair; Lippincott Co., U.S.A.
2. "Steel Works Analysis," Arnold and Ibbotson; Whittaker and Co.
3. "The Analysis of Steelworks Materials," Ibbotson and Brearley.

Of the remaining publications the following are the most important:—

4. 1901. "Methods of Iron and Steel Analysis," Phillips; The Chemical Publishing Co., U.S.A.
5. 1908. "Practical Methods for Iron and Steelworks Chemists," Hesse; The Chemical Publishing Co., U.S.A.
6. 1909. "Rapid Methods for the Analysis of Special Steels," Johnson; Wiley and Sons.
7. 1909. "Laboratory Notes on Iron and Steel Analysis," McFarlane; Longmans, Green, and Co.
8. 1910. "Iron and Steel Analysis," Vol. I., Campion; Fraser Asher and Co., Glasgow.
9. 1914. "Modern Steel Analysis," Pickard; J. and A. Churchill.
10. 1915. "The Sampling and Analysis of Iron Steel," Bauer and Derss; Hall and Williams.

It would be invidious to select any of these for special mention, but it may be pointed out that No. 4 is a symposium of the methods in use in American practice.

No. 6 is more particularly devoted to the analysis of special alloy steels.

No. 7 is descriptive of the methods in use in the Midlands and the North-East Coast of England.

No. 8 *represents Scottish practice to a large extent.*

No. 9 gives a useful summary of some processes for the determination of the less frequently determined elements in iron and steel.

No. 10 gives a review of German practice.

It is quite possible that new editions of these books may have appeared, as my own connection with this branch of industry was severed a good many years ago.—I am, &c.,

Lawrence Crawford.

The Sanquhar and Kirkconnel Collieries, Ltd.,
Sanquhar, N.B., June 22, 1918.

NITROMETER METHOD FOR PHOSPHORUS.

To the Editor of the Chemical News.

Sir,—An interesting paragraph appears in the Chemical News (cxvii., 227) relative to a nitrometer method for the determination of phosphorus, by J. Clarens.

The observation of Clarens that by using a particular mixture for the precipitation of the phosphorus as ammonium phosphomolydate, which he specifies, the ratio of the ammonium radicle to phosphorus is fixed, seems to imply that any other mixture would give a contrary result.

This is not so; for some time ago I applied a similar method for the determination of phosphorus in steels, and by using a totally different mixture for precipitation obtained results from which I drew the same conclusion as your correspondent.

The method, while being accurate and reliable, is not to be recommended where time is an important factor, such as in a steel works laboratory.—I am, &c.,

Joseph Shibko.

MISCELLANEOUS.

Students of Chemistry and Military Service.—The *Registrar of the Institute of Chemistry* has received a letter from the Board of Education stating that the Ministry of National Service has cancelled the arrangements made in connection with military service of students of chemistry. The effect of this cancellation is that any student of chemistry in Category B (i.), C (i.), or B (ii.), or in Grade 2 who has hitherto been protected under the arrangements in question, will be called up if otherwise available for service.

Qualitative Analysis and the Cyanogen Compounds in Steel.—The existence of gases in steel at the present day, especially that of cyanogen, may be an occlusion, as we have evidence of earlier formation of it in the earth's vaporous condition before man inhabited it; or, at any rate, of its existence in the sun, or other reasons to believe its existence at a high temperature may be the cause of the peculiar colour when estimating phosphorus in steel with ammonium molybdate, ferrocyanide being formed; the bluish colour is noticed against the permanganate tints of a collateral manganese estimation, and we are not inclined to think the ammonium radicle in steel likely to be broken up in the reaction.—J. C. Thomlinson, B.Sc.

Literary Intelligence. — An Italian work entitled "Chemical Combination among Metals," by Dr. M. Giua, has been translated into English by Mr. G. W. Robinson, of Bangor, and is to be published by J. and A. Churchill. This book deals with a subject which has of late years become increasingly important in the sphere of general and inorganic chemistry. The subject is considered at length, together with its bearing on the general question of valency. The relation between chemical composition and physical properties is fully discussed. The main portion of the book consists of a valuable account of all intermetallic systems in which compounds occur. A very full bibliography is given in the notes.

Royal Society of Arts Medals.—The Council have awarded the Society's Silver Medal to the authors of the following papers read before the Society during the past Session:—W. Lawrence Balls, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners and Doublers' Association, "Examples of Applied Science in the Cotton Industry." George Martineau, C.B., "Sugar from several Points of View." John B. Farmer, F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry." Martin O. Forster, D.Sc., F.R.S., "Organic Chemistry in Relation to Industry." H. M. Surtees Tuckwell, M.Mech.E., "The Tata Iron and Steel Works." Sir Walter Egerton, K.C.M.G., Governor of British Guiana, 1912-17, "British Guiana and the Problem of its Development."

British Scientific Products Exhibition.—The British Science Guild is organising a comprehensive exhibition of products and appliances of scientific and industrial interest which prior to the war were obtained chiefly from enemy countries but are now produced in the United Kingdom. His Majesty the King has graciously consented to become Patron of the Exhibition, and the Marquess of Crewe, K.G., is President. Among the Vice-Presidents are:—The Prime Minister; Mr. Winston Churchill, Minister of Munitions; Sir Albert Stanley, President of the Board of Trade; Mr. H. A. L. Fisher, President of the Board of Education; Dr. Addison, Minister of Reconstruction; Lord Moulton; Lord Sydenham; Sir J. J. Thomson, President of the Royal Society; Sir W. Crookes; and other distinguished public men. The Exhibition, which will be held at King's College from about the first week in August until the first week in September, will show, in the first place, products chiefly imported from Germany before the war but now made in this country; but it will also illustrate the remarkable developments that have taken place generally in our scientific industries. In many of these, as a matter of fact, Great Britain always excelled, and it is only our national quality of self-depreciation which has prevented the public from appreciating the fact that we were able to export to Germany apparatus and products embodying the highest scientific knowledge and technical skill. The general scope of the Exhibition has been set forth in a preliminary leaflet which has been issued, from which it is noted that the exhibits will include chemical products, thermal, electrical, and optical appliances, glass, quartz, and refractory materials, photographic apparatus and material, surgical and medical appliances, and papers and textile products. It is believed that the effect of the Exhibition will be to have a most stimulating influence upon scientific and industrial research, and the exhibits, and the demonstrations and lectures that will be given in order to explain them, will undoubtedly bring home to manufacturers, as well as to the general public, the great and growing part that science plays in industry. Further particulars may be obtained from the Organising Secretary, F. S. Spiers, 82, Victoria Street, London, S.W. 1.

TO comply with Regulation 8 (b) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

ANALYTICAL CHEMISTS. — Assistants required, over 23 or ineligible for Army. Experienced Analysts. Steel works experience preferred, but not essential. No person already engaged on Government work will be engaged.—Apply your nearest Employment Exchange, quoting reference No. A 5611.

Wanted, Metallurgical Chemist capable of taking control of 30-cwt. "Heroult" Electric Furnace working on high-class Steels.—Applicants must state age, experience, and wages expected, and apply to their nearest Employment Exchange, quoting No. A 5610. No person already on Government work will be engaged.

Works Analytical Chemist required. One conversant with Soap Manufacture, Nicotine Extractions, and Agricultural and Horticultural Preparations. State full particulars and salary required.—Address, W. A., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Youth (16) requires berth in Analytical or Experimental Laboratory. Experience.—Address, Compton, 93, Commercial Road, S.E. 15.

Wanted, good ANALYTICAL BALANCE. Any make, Sartorius or Bunge preferred.—Address, "Balance," Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted urgently, copy METALLURGICAL AND CHEMICAL ENGINEERING dated September 15th, Vol. XVII., No. 6.—R. C. Baggs, H.M. Factory, Oldbury.

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In consequence of the "No Returns Order" of the Government, readers of the "Chemical News" are requested to ensure a regular supply of the paper by placing an order with their Newsagent.

THE CHEMICAL NEWS

VOL. CXVII., No. 3052.

SPECIAL NOTICE TO SUBSCRIBERS.

WE regret to announce that the recent paper restrictions will compel us for a period, until we can secure our usual supply of paper, to publish the CHEMICAL NEWS fortnightly instead of weekly.

The price will not be altered, except as regards the subscription price, which, until further notice, will be calculated at £1 for fifty-two numbers, or *pro rata*.

Subscribers will please note that the respective expiration dates of their subscriptions will be extended accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their extended subscription periods.

The next issue (No. 3053) will be published on August 2nd.

THE BOILING-POINTS OF THE PARAFFINS.

By GERVAISE LE BAS.

ONE of the few rules correlating the boiling-point of compounds and chemical constitution, due to Hinrichs and Naumann, has stood for several decades without qualification or amplification. The idea is that the more considerable the branching of the chain, or, on the other hand, the more compact the molecule, the lower is the boiling-point.

A further consideration of this question shows that the real causes of the regularity are not brought out by the rule, and in any case the rule is not always followed.

The diminution of the boiling-point is found to depend on the substitution of the β, γ, and δ . . . carbon atoms by methyl groups. It is not difficult to show that the lowering of the boiling-point is proportional to their number.

In dealing with the question it is necessary to consider the iso-structure. It is sometimes the practice of writing the formula of iso-compounds as follows:—

$$\begin{matrix} CH_3 \\ CH_3 \end{matrix}\!\!>C-R,$$

the assumption being that it consists of two similar methyl groups attached to one carbon atom.

From the point of view of boiling-points this is not true. This class of structure involves the substitution of the hydrogen of α, β, γ, δ . . . carbon atom of hydrocarbon chain by a *single methyl group*. The difference in boiling-point due to this structure is 6° or 7° when substitution of the β-methylene group has been effected, and slightly more—9°—when the γ-methylene group has been substituted.

Two Methylalkanes.

	B.p.	Δ.
(*a*) One substitution :—		
$CH_3.CH(CH_3).CH_2.CH_3$	30	
		−8
n-Pentane	38	
$CH_3.CH(CH_3).C_3H_7$	62	
		−7
n-Hexane	69	
$CH_3.CH(CH_3).C_4H_9$	90·3	
		−7·7
n-Heptane	98	
$CH_3.CH(CH_3).C_5H_{11}$	118	
		−7
n-Octane	125	
$CH_3.CH(CH_3).C_6H_{13}$	143	
		−7
n-Nonane	150	
(*b*) Two substitutions :—		
$CH_3.CH(CH_3).CH_2.CH_2.CH(CH_3).CH_3$	108·5	
		−16·5
n-Octane	125·0	
		2×8·2
$CH_3.CH(CH_3).CH_2.CH_2\ CH_2.CH(CH_3).CH_3$	135·0	
n : 4-Dimethyl heptane gives	133°	
2 : 5-Dimethyl heptane gives	136°	
		−15·0
n-Nonane	150	
		2×7·5
$CH_3.CH_2.C(CH_3)_2.CH_2.CH_3$	86·0	
		−12·0
n-Hexane	98·0	
		2×6·0
(*c*) Three ubstitutions :—		
$CH_3.CH(CH_3).CH(CH_3)\ CH_2.CH(CH_3)\ CH_3)$	130·0	
		−20·0
n Nonane	150·0	
		3×6·6

Substitution of the γ-group may take place :—

$CH_3.CH_2.CH(CH_3)\ CH_2.CH_3$	60	
		−9·0
n-Hexane	69	

The difference is somewhat greater than for β-substitution.

This follows a rule given by Gartenmeister as a result of his examination of the aliphatic esters, except that in these cases the difference diminishes as substitution towards the centre proceeds. The significance of this difference will be given later. (See Note 1).

When the CH_3 group is replaced by one of greater complexity the diminution nearly disappears.

n-Heptane	98·0	
		−9·0
$CH_3.CH_2.CH(CH_3).C_3H_7$ ..	[89·0]	
		−2·0
$CH_3.CH_2\ CH(C_2H_5).C_3H_7$ ..	96·0	

This is striking evidence in favour of the view that the diminutions are connected with the substitution of hydrocarbon chains by methyl groups.

Three Methyl Groups.

$\begin{matrix} CH_3 \\ CH_3 \end{matrix}\!\!>CH-CH_3$ .. .. .. Trimethyl methane.	−17·0	
		−18·0
n-Butane	+1·0	
		3×6·0
$CH_3-C(CH_3)_2-C_2H_5$ .. .. .. Trimethyl propane.	49	
		−20·0
n-Hexane	69	
		3×6·6

The boiling-point of the above compound is probably 48°.

Four Methyl Groups.

$$\begin{array}{c} CH_3 \\ | \\ CH_3-C-CH_3 \\ | \\ CH_3 \end{array} \quad \ldots\ldots\ldots \quad 9.5$$

Tetramethyl methane.

		−28.5
		4×7·1
n-Pentane	38·0	

It is seen that when the β methylene group is substituted by two methyl groups, the number to be counted is three or four as the case may be, never two. Under the circumstances the terminal methyl groups of the original hydrocarbon chain have to be taken into consideration.

$(CH_3)_3.C.CH_2.CH_2.CH(CH_3)CH_3$.	120°	
n-Nonane	150	
		−30
		4×7·5

This is 1 : 1 : 1 : 4 tetramethyl pentane and not 2 : 2 : 5 or ββε-trimethylhexane as stated.

It should be remarked that when two contiguous carbon atoms are united to methyl groups there is an augmentation of the boiling-point of about 4° ; *e.g.*, diisopropyl :—

$$\begin{array}{l} CH_3.CH.CH.CH_3 \\ \quad\ \ |\quad\ \ | \\ \quad CH_3\ CH_3 \end{array} \quad \ldots\ldots\ldots \quad 58°$$

2 : 3-Dimethyl butane.

		11	
n-Hexane	69		
Two methyl groups (rise)		16	2×8
		5	

$$\begin{array}{l} CH_3.CH-CH.CH_2.CH(CH_3)CH_3 \\ \quad\ \ |\qquad\ | \\ \quad CH_3\ \ CH_3 \end{array} \quad 130$$

1 : 2 : 5-Trimethyl hexane

		20	
n Nonane	150		
Three methyl groups rise		24	(3×8)
		4°	

It will be seen that there is in the above relations justification for the nomenclature advocated by the Geneva Convention. (See Note 2).

It follows that many of the names and formulæ given to compounds are not correct.

The iso-structure has been commented on. Also—

$$CH_3.CH{<}^{C_2H_5}_{C_2H_5}$$

methyl diethyl methane—

$$CH{\begin{array}{l} \diagup C_2H_5 \\ -C_2H_5 \\ \diagdown C_2H_5 \end{array}}$$

triethyl methane, *are terminological inexactitudes.*

The two compounds are derivatives of pentane ; in fact, γ-methyl pentane, and the second γ-ethyl pentane.

Notes.

1. In endeavouring to get some idea of the causes of the above changes it must be noted that the boiling-point diminishes as the number of methyl groups accumulate in the molecule, and the mere branching of the chain does not necessarily produce any great change in the boiling-point. The diminution of the boiling-point indicates that the presence of methyl groups diminishes the residual affinity, or, at any rate, the intermolecular cohesion. This may be due to the fact that in the methyl group there is a greater proportion of hydrogen than in the methylene groups, and since this substance in the elementary state has a very low boiling-point as well as abnormally large volume, there is imparted to the broken chain compounds similar characters provided the substituents be methyl groups and not ethyl or more complex groups. The theory of molecular volumes shows that the abnormal volumes of methane and ethane, &c., are due to the corresponding expansion of carbon as well as that of hydrogen (vide *prox.*).

2. Two contiguous methyl groups cause a rise in boiling-point owing to their mutual action in increasing the residual affinity or intermolecular cohesion. This applies to two methyl groups in the ortho-position (see Chemical News, 1918, cxvii., 121). The simpler paraffins—that is, those with the terminal methyl groups near together—have also very low boiling-points, &c., the view being that the substituting methyl groups have to some extent the properties of methane.

It follows that Hinrichs and Naumann's rules are not necessarily true, and the generalised statement of the regularity needs to be changed in the manner indicated, at any rate for the hydrocarbons. This would no doubt be supported by the consideration of complex hydrocarbons, the substituents of the main chain being residues more complex than CH_3 ; say, C_3H_7—, C_4H_9—, C_5H_{11} *e g.*, $C_5H_{11}.CH(C_3H_7).C_2H_5$.

THE ESTIMATION OF POTASH.

By BERTRAM BLOUNT, F.I.C.

Potash is now a material of national interest, and its estimation with accuracy is the root of the whole matter. Such things as felspar, blast-furnace flue dust, the dust from cement kilns, were commonly disregarded as potential sources of potash, but the stern necessities of war have taught us to be no longer dependent on the Stassfurt deposits. Usually analyses of silicate rocks, clays, cements, and the like have hitherto ended with "alkalis and loss" or "perte et divers," both phrases quite sufficient for the purpose in view. And here I may remark that of the many thousands of analyses of such materials published by German chemists there is hardly one which does not say "alkalis so much per cent"—which, of course, is impossible unless the mixed oxides are isolated and weighed as such. If weighed jointly as sulphate, as is often done, no such return is possible, and if they are computed by estimating the sulphuric anhydride, then they should be stated separately.

With soluble materials containing potash there is little difficulty save in the later stages of the process, but in the *case of the substances cited above some complications* may arise.

Substances containing potash in a soluble form can be *leached out and the potash estimated in the usual way.* What potash can be regarded as soluble has to be decided by an arbitrary method ; it is generally agreed that the *citric acid process is suitable. But, as in the case of basic* slag, the material may be available although not immediately soluble.

Therefore it comes to this : *that the whole of the potash* in whatever form in any substance shall be estimated. Such a method is on a par with the absolute method of Dumas for nitrogen. All that is needed is the potash—as in the Dumas case, the nitrogen.

Taking, then, a general basis, it may be said that the sound principle of eliminating everything from the substance analysed, except the substance to be determined, must be adopted. Everything must be cleared out. Short-cuts, useful for particular purposes, are practically useless in this case. Blank tests must be made throughout, and analyses of mixtures containing a known amount of potash are desirable. The method used in my laboratory is as follows :—

Method for the Estimation of Potash in Siliceous Rocks, Clays, &c.

Opening up.—It is essential that the whole of the material should be in solution, and for this purpose many different methods have been suggested, such as that by Lawrence Smith. In practice, however, I have found that treatment by hydrofluoric acid, together with sulphuric acid, is by far the most accurate and satisfactory method.

The method which I have adopted is as follows:—A small portion of the bulk ground sample is very finely ground in an agate mortar, and if necessary dried again. One-half a grm. to 2 grms. is weighed out and transferred to a fair-sized platinum crucible, and digested for two or three hours with 10 cc. purest hydrofluoric acid (that supplied in cerasin bottles) and 2 cc. sulphuric acid (*puriss.*). If necessary, a further 10 cc. of hydrofluoric acid is added, and the whole gently evaporated till most of the sulphuric acid has been fumed off, great care being taken to prevent loss by "spurting." The anhydrous sulphates are taken up by digesting with hydrochloric acid, and the diluted solution filtered off through a small filter, retaining the insoluble matter in the dish. This is further digested with hydrochloric acid and filtered off as before, and if any residue still remains, which is usually due to insufficient attack, it is washed on to the filter paper, which is then thoroughly washed, dried, very gently ignited in a platinum crucible, and the above process of treatment with hydrofluoric acid, &c., repeated. The original grinding in the agate should be so thorough that further grinding at this stage should be unnecessary, as it would involve loss. In the case of materials such as limestone, &c., the bulk of which can be readily dissolved, the method is modified, in that the material is first digested with hydrochloric acid, and the insoluble portion is then treated as above and added to the main solution.

Removing other Constituents.—The iron, alumina, and manganese are removed by the addition of bromine and ammonia and a short digestion. The precipitate is filtered off and thoroughly washed. Ammonia is added to the filtrate and the whole boiled. Ammonium oxalate is then added and the whole boiled up again. After the precipitate has been allowed to settle, the calcium oxalate is filtered off and washed thoroughly, and the filtrate gently evaporated to a low bulk. The basin is then covered and sufficient nitric acid is added to destroy the ammonium salts, and, whilst still covered, the whole is evaporated till just dry, or till fumes of sulphuric acid appear. After cooling, the residue is taken up in 2 or 3 cc. of hydrochloric acid and a little water, and gently evaporated to low bulk. The solution is diluted, a small excess of a clear solution of barium hydrate is added, and the whole digested for about half-an-hour, during which time a slight skin of barium carbonate should form on top, showing that an excess is present. The precipitate is filtered off and thoroughly washed, and the filtrate digested with excess of ammonium carbonate, and the precipitated barium carbonate filtered off and washed. The filtrate is evaporated to low bulk on a water-bath, a few cc. of hydrochloric acid are cautiously added, and the whole transferred to a small platinum dish and evaporated to dryness on a water-bath. The residue is very gently ignited over an argand burner to drive off all the ammonium chloride, the crude alkali chlorides dissolved in a small quantity of water, a drop or two of ammonium carbonate added, and digested for a minute or two, and the whole filtered off through a very small filter with thorough washing into a weighed platinum dish. The filtrate is evaporated on a water-bath and the residue carefully ignited over an argand, cooled in a desiccator, and weighed. This is the weight of the pure alkali chlorides.

As potash adheres very persistently to all the precipitates and filter-papers, it is absolutely essential that the washings should be very thorough at all the various stages. It is better to have to remove traces of any slightly soluble precipitate such as magnesia from the crude alkali chlorides than to run the risk of leaving some of the potash in the precipitates or filter-papers.

Separation of Potassium from Sodium.—Although many methods have been tried, such as the cobaltinitrite and perchlorate methods, the older method of platinic chloride still seems the best where accuracy is required. The pure alkali chlorides, obtained as above, are dissolved in a small quantity of water (and should of course leave no residue) and sufficient platinic chloride added to combine with the whole of the potassium and sodium salts and leave a slight excess. The solution is evaporated on the water-bath till it begins to get pasty, then cooled, diluted with a sufficient quantity of 80 per cent alcohol by volume to take up the whole of the sodium salt, and allowed to stand for a few hours. If the quantity of alkali is large, it is better to take up the pasty chlorides in a small measured quantity of hot water, cool, and add sufficient absolute alcohol to bring the final solution to 80 per cent by volume.

The precipitate of potassium platinic chloride is filtered off, washed with 80 per cent alcohol till quite free from sodium salts, warmed to drive off the alcohol, and then dissolved through into a weighed platinum dish by means of boiling water, evaporated to dryness, dried in an air oven, cooled, and weighed.

Platinum Residues.—Many methods have been published, reference to some of which is given below.

The best and shortest way is to take the whole mass to dryness and ignite to full redness (1100° C.). The mass is ground finely and extracted with water, then with hydrochloric acid, washed well, and then extracted with nitric acid. The residue is again ignited and extracted with aqua regia. The solution is evaporated to dryness and taken up with HCl and water.

All solutions except the first aqueous extract are returned to be worked up with the next batch.

References.—Mellor, "Treatise on Chemical Analysis," p. 240. Crookes, "Select Methods in Chemical Analysis," p. 462. *Journal of Society of Chemical Industry*, 1897, p. 642; 1901, p. 902. And many of the ordinary text books.

Addendum.—On account of the scarcity of platinum it is advisable to have an alternative method. The best of these is the perchlorate process, and a good account is given by Mellor in "A Treatise on Quantitative Inorganic Analysis," p. 237, which is here transcribed.

The Process.—"Dissolve the mixed chlorides (see Note) in from 10 to 15 cc. of hot water, and then add two or three times as much perchloric acid as is theoretically required to precipitate the mixed perchlorates. Evaporate the mixture on a water-bath to a syrupy liquid until the fumes of perchloric begin to appear; cool a little. Take up the mass with hot water, and add 5 to 6 cc. of perchloric acid. Re-evaporate until the fumes of perchloric acid again begin to appear. The object of this treatment is to remove the hydrochloric acid. This is important. Stir the cold mass with about 20 cc. of 96 or 97 per cent alcohol containing 0·2 per cent by weight of perchloric acid. Keep the potassium perchlorate as coarsely granular as possible. Let settle. Decant through a dried and weighed Gooch's crucible. Wash the residue by decantation through the Gooch's crucible three times. About 20 cc. of the alcohol will be needed for the washing. Transfer the precipitate to the Gooch's crucible by means of alcohol. Some prefer to wash the residue at this stage with 20 cc. of a mixture of equal parts of 97 per cent alcohol and ether. Dry the precipitate at 120—130° for about half-an-hour, and then weigh as $KClO_4$."

(NOTE.—The amount is calculated as follows:—Assume that the mixed chlorides are all sodium chloride, and that the perchloric acid used is 30 per cent (sp. gr. 1·20) solution). Multiply the weight of the mixed chlorides by 6, and the product represents the number of cc. of acid required for the work. Perchloric acid of approximately 60 per cent strength has a sp. gr. of 1·54; 30 per cent, 1·20; and 20 per cent, 1·12. There is no difficulty about keeping the acid. It is not decomposed by hydrochloric or by sul-

phurous acid. The acid slowly volatilises at 138° C. *without decomposition. It is not affected by exposure to* light. The strength of the acid is easily determined by titration of a known amount with standard sodium hydroxide with phenolphthalein as indicator).

The process given in the main paper is followed strictly until the mixed chlorides are isolated in a pure state. They are then separated by the perchlorate method instead of by the use of platinic chloride. In other respects the operations are identical.—*The Analyst*, April, 1918.

EXTRACTION OF RADIUM FROM AMERICAN PITCHBLENDE ORES BY CHLORINATION.

By Mrs. RAY CABLE and HERMAN SCHLUNDT.

The uraninite in the pitchblende ores of Gilpin County, Colorado, occurs very intimately associated with iron pyrites. Apparently no satisfactory method of separating the uranium minerals from the pyrites by mechanical methods has been developed. Concentration of the ore by the ordinary mill operations results in several products ranging in content of uranium oxide, U_3O_8, from 1 per cent to 25 per cent. The final blending gives three grades:—High-grade, containing upwards of 16 per cent U_3O_8; medium-grade, averaging about 4 per cent; and low-grade containing less than 2 per cent U_3O_8. The main body of all grades, however, is iron pyrites.

The extraction of radium from these ores has been carried out successfully on a commercial scale by methods developed in the U.S. Bureau of Mines. During the summer of 1916 one of us assisted for a time in the laboratory experiments conducted in the Mining Experiment Station of the U.S. Bureau of Mines at Golden, Col., preliminary to plant operations. We were thus brought face to face with some new problems in radium extraction from an ore differing fundamentally from the European pitchblendes in its distinctively high content of sulphide minerals. Subsequently we continued our investigations on these ores in the chemical laboratory of the University of Missouri. The experimental results here presented summarise the results obtained by a new method of extracting radium by direct chlorination of the ore. We are indebted to Dr. R. B. Moore, Superintendent of the Golden Station, for the samples of ore used in these experiments.

The Reaction.

When the ore is heated in an atmosphere of chlorine, interaction takes place readily. The principal products of the reaction are sulphur monochloride, S_2Cl_2, and chlorides of the metals present. The reaction of chlorine with iron pyrites takes place mainly according to the equation, $2FeS_2+5Cl_2 = 2FeCl_3+2S_2Cl_2$, and is an example of one of the general methods of preparing sulphur monochloride. By conducting the reaction in a stream of chlorine gas the chloride of iron together with chlorides of uranium appear as a crystalline deposit in the cooler parts of the apparatus, while the more volatile product, sulphur monochloride, can be separated as a gas which is easily condensed and collected in a receiver. Chlorination probably converts the radium into chloride, which, contrary to our expectations, is also carried forward in the current of chlorides, a relatively small fraction only remaining with the unattacked constituents of the ore.

Upon the addition of water to the residue and anhydrous chlorides of the metal a very vigorous interaction occurs. The radium compounds for the most part remain in solution. After filtering off the small insoluble residue, the radium can be precipitated very nearly quantitatively as radium-barium sulphates by adding to the filtrate a little barium chloride solution and its equivalent of sulphuric acid. The addition of sulphate ions to precipitate the radium-barium sulphates is, as a rule, not necessary, inasmuch as a small quantity of sulphates is generally produced in the course of the chlorination. The reason for the radium not precipitating in the presence of sulphates when the chlorides are treated with water, we are inclined to attribute to the lack of sufficient barium in the ore. Recent determinations of the solubility of pure radium sulphate conducted by Lind, Underwood, and Whittemore (*Journ. Am. Chem. Soc.*, 1918, xl., 3) in the Golden Station of the U.S. Bureau of Mines have fixed the solubility of radium sulphate in water as approximately a hundredfold less than that of barium sulphate. Nevertheless the minute quantities of radium in the solutions here under consideration still lie below the solubility product of radium sulphate. However, when radium sulphate is precipitated together with a large excess of barium sulphate the solubility of radium sulphate is far below the actual solubility of radium sulphate. Hence precipitation of barium sulphate in quantity a hundredfold or more the solubility of barium sulphate in the solution results also in a practically quantitative precipitation of the radium.

The Ore Samples.

Experiments were conducted with the three grades of ore designated respectively low, medium, and high grade. The radium content of each grade was determined quantitatively by separating the emanation from weighed samples, and measuring the ionisation current product by it in standardised electroscopes. (For a description of the method and the apparatus used see Lind, "Practical Methods for the Determination of Radium," *Journ. Ind. and Eng. Chem.*, 1915, vii., 406 and 1024; see also Schlundt and Moore, *Journ. Phys. Chem.*, 1905, ix., 320). The percentage of uranium was computed by multiplying its radium content by the established constant, 3×10^6, for the ratio of uranium to radium in primary uranium minerals. The analytical results thus obtained appear in the tabulated summary given herewith. The percentage of uranium in the high grade ore was also determined by chemical analysis in the laboratory of the Bureau of Mines, and found to be 17·58 per cent U_3O_8, a value in close agreement with the uranium oxide equivalent of 17·45 per cent calculated from the radium content. Since some emanation is continuously liberated from the ore under ordinary conditions of temperature and pressure it is necessary in making radium determinations on samples not previously sealed until equilibrium has been attained to determine the emanating power on another sample. We found that the emanation lost in the cold ranged from 6 to 9 per cent of the total in the different grades. The values for the radium content given in the table are, of course, based upon the equilibrium quantity of emanation.

In making the radium determinations the emanation was separated by dissolving suitable quantities of the finely-ground ore in 40 per cent nitric acid and collecting the gaseous products in a gas burette over a hot solution of sodium hydroxide. The interaction of hot nitric acid with the sulphides of the ore produces several oxides of nitrogen, one of which, nitric oxide, is absorbed only very sparingly by the alkaline solution. As a result the volume of gas in determinations where samples of about a grm. of ore were required was found to exceed the capacity of our gas burettes. This difficulty in the usual procedure may be overcome either by largely displacing the air in the reaction flask with oxygen before introducing the nitric acid, or by admitting oxygen into the burette from time to time during the progress of the reaction. Oxygen converts nitric oxide into nitrogen peroxide, NO_2, which is readily absorbed in the solution of lye.

The Experiments.

For chlorination, the ore in charges of 30 to 35 grms. was spread out over about one-third the length of a 1¼ meter piece of hard glass combustion tubing of fully 2 cm. diameter, fitted at both ends with one-hole rubber stoppers. The ore charge was heated in a long combustion furnace of the type usually employed for combustion

TABLE I.—*Summary of Results.*

Grade of ore.	Low.	Medium.	High
1. Radium content of ore, parts per billion	3·43	8·312	49·27
2. Uranium content of ore, expressed as U_3O_8	1·20 per cent	2·92 per cent	17·45 per cent
3. Weight of ore used	32·0 grms.	35·0 grms.	35·0 grms.
4. Weight of tailings	3·30 grms. = 10·32 p.c.	0·795 grm. = 2·27 p.c.	3·53 grms. = 10·09 p.c.
5. Total radium in ore sample	109·8 × 10^{-9} grms.	290·9 × 10^{-9} grms.	1724·5 × 10^{-9} grms.
6. Weight of sulphates recovered	0·0938 grm.	0·237 grm.	0·635 grm.
7. Radium recovered in sulphates	102·5 × 10^{-9} grms.	267·1 × 10^{-9} grms.	1615 × 10^{-9}
8. Radium recovered in sulphates	93·34 per cent	91·78 per cent	93·68 per cent
9. Concentration of radium in sulphates—parts per billion	1084	1127	2543
10. Concentration ratio	316 : 1	135 : 1	51·6 : 1
11. Radium losses:—			
(a) In tailings—emanation method	1·954 × 10^{-9} g. = 1·74 p.c.	4·36 × 10^{-9} g. = 1·53 p.c.	56·6 × 10^{-9} g. = 3·29 p.c.
(b) In liquors—emanation method	4·23 × 10^{-10} g. = 0·34 p.c.	1·49 × 10^{-9} g. = 0·51 p.c.	4·43 × 10^{-9} g. = 0·26 p.c.
12. Radium unaccounted for	4·58 per cent	6·18 per cent	2·77 per cent

analysis of organic compounds. On the one hand, the tube was connected with a tank of liquid chlorine, and on the other with a condenser and receiver. A wash bottle containing sulphuric acid was placed in the train next to the chlorine tank, and this was followed by a T-tube dipping into mercury which served as a vent for the escape of chlorine in case the products of the reaction ever clogged up the outlet end of the tube. A plug of glass-wool was inserted near the outlet end of the tube to stop small amounts of metallic chlorides that are apt to be swept along by vapours of sulphur monochloride when chlorination is rapid. In the early experiments the ore charge was placed in several porcelain boats, but after finding that only a small fraction of the radium remained with the unattacked residue the boats were no longer used.

The chlorination was conducted by heating moderately at first with a slow stream of chlorine passing until rapid reaction starts, which occurs before low redness is reached. The supply of chlorine was then materially increased and the temperature gradually raised to low redness. The metallic chlorides formed are deposited along the tube beyond the heated portion, and sulphur monochloride passes on to the condenser if the cooler part of the tube is kept at a temperature above 137°, the boiling-point of the monochloride.

Chlorination of the low grade ore was at first carried out with samples ground to pass through an 80-mesh sieve, but when it was found that this degree of comminution is not necessary for complete chlorination, ore of 20 mesh was used in the subsequent experiments with medium and high grade ores. Several of the chlorinations lasted three to five hours, but in most of the experiments the flow of chlorine was so regulated that a charge of 35 grms. was completely chlorinated within an hour. Turning the tube a little with an occasional tapping saves time.

When the tube had cooled it was taken from the furnace and the contents washed out with water or very dilute hydrochloric acid. After boiling the insoluble residue, the tailing was filtered off, washed, ignited, and weighed. The filtrates were again heated to boiling and radium precipitated by adding a few cc. of a 10 per cent solution of barium chloride and an excess of sulphuric acid. Three or four days after precipitation the sulphates were filtered off, ignited, weighed, and finally assayed for radium. The liquors were diluted to 500 cc., and samples of 200 cc. were boiled and sealed up for quantitative determinations of radium remaining in solution.

Complete duplicate experiments were conducted with each grade of ore. The recovery of radium in the sulphates, and the losses of radium in the tailings and liquors were determined by the emanation method. Carefully standardised electroscopes (Leaming, Schlundt, and Underwood, *Trans. Am. Electrochem. Soc.*, 1916, xxx., 375) of the interchangeable type designed by Dr. Lind (*loc. cit.*), of the Bureau of Mines, were used in the radium determinations, and use was made of the apparatus for boiling off and transferring the emanation described by the same author. Small samples (20 mgrms.) of the radium bearing sulphates were fused with mixed carbonates of sodium and potassium in small platinum boats, which were then stored in sealed tubes for definite periods and finally decomposed with 1 : 1 nitric acid in an apparatus for collecting the emanation quantitatively. For determinations of radium in the tailing samples about half the quantity of insoluble residue from 35 grms. of ore was fused with mixed carbonates in platinum crucibles, the melt poured out into an iron mortar, powdered, and then sealed in thin glass bulbs. After several days of storage the accumulated emanation was separated by decomposition with nitric acid. Details of the procedure and calculation of the results are given in some of the references cited.

The Results.

The experimental results are summarised in Table I.

The recovery of radium is satisfactory for each grade of ore, and the radium content of the sulphates lies well within the limit required for further concentration by fractional crystallisation after conversion of the sulphates into chlorides. The concentration ratios were computed by dividing the figure for the concentration of radium in the sulphates by the radium content of the grade of ore from which the sulphates were recovered. The radium losses given for the liquors are probably too low, inasmuch as our method of testing simply accounts for the radium actually in solution and does not include possible traces of radium carried in suspension. We are therefore inclined to assign the percentages of radium unaccounted for at least in large part to this avenue of loss, because a second precipitation of barium sulphate in the liquors invariably gave a "second" sulphate of higher radium content than the loss found in the liquors by our method of testing. We are convinced that the loss of radium in the sulphur monochloride is negligible. In one experiment the residue left upon evaporation of the chloride when tested by the ordinary α-ray method showed no activity whatever.

It would be interesting to ascertain whether the radium in the deposit of metallic chlorides can be further concentrated by volatilising the anhydrous chlorides again. Perhaps the radium would then remain for the most part in the non-volatile residue.

We hope to extend the investigations in the near future to larger samples of ore.

A few chlorination experiments with carnotite ore did not give results of promise for a method of extracting radium.

The chlorination experiments with low grade ore represent one phase of a more extended investigation on the extraction of radium from pitchblende ores to be submitted by Mrs. J. Ray Cable as a thesis in partial fulfilment of the requirements for the degree of Master of Arts. University of Missouri.—*Metallurgical and Chemical Engineering*, xviii., No 9.

AGRICULTURAL RECONSTRUCTION.

The Selborne Report and what it Proposes.

In August, 1916, a Sub-Committee of the Reconstruction Committee was appointed to consider and report upon the best methods of increasing home-grown food supplies in the interest of national security. The Chairman was the Earl of Selborne, and the members included Sir Charles Bathurst, Sir Ailwyn Fellowes, Sir Matthew Wallace, Sir Daniel Hall, Mr. R. E. Prothero, Mr. G. H. Roberts, Mr. E. G. Strutt, Mr. C. M. Douglas, Mr. W. J. Fitzherbert-Brockholes, Mr. W. A. Haviland, Mr. C. Bryner Jones, and Mr. G. G. Rea. Later, Sir Horace Plunkett and Dr. Kelly (Lord Bishop of Ross) were added to the Committee, which in January, 1917, issued the first part of its Report, the members being unanimous as to its proposals, with the exception of Sir Matthew Wallace, who signed a Minority Report.

The first Report, it may be remembered, recommended the establishment of Wages Boards and a minimum wage for agricultural labourers; it also recommended that minimum prices for wheat and oats should be guaranteed, the payment being based on the difference between the price guaranteed and the average price for the year and on the number of quarters actually harvested. Further, the Committee recommended that the Board of Agriculture should be given certain powers to enforce the proper cultivation of land, and that the Government should take measures to encourage the growing of sugar-beet in this country and the home production of sugar. All these recommendations have since been embodied in legislation or in Orders issued from time to time.

A Comprehensive Survey.

The second part of the Committee's Report, recommending definite reforms in agricultural administration and organisation, is now ready, and the whole Report has been published with an historical preface by Mr. Alexander Goddard, one of the Secretaries of the Committee. Prof. Biffen, Mr. W. C. Fielding, Mr. J. R. Cahill, Mr. John Ross, Sir H. Trustram Eve, Mr. T. H. Middleton, and others contribute appendices on different branches of the subject. The whole document forms a most comprehensive survey of British Agriculture and embodies a drastic policy of Agricultural Reconstruction. Sir Matthew Wallace has again found himself unable to sign the Committee's Report, and has written a dissenting memorandum explaining the points on which he differs from his colleagues.

In their conclusions, the Committee emphasise the fact that the problem has been approached not from the standpoint of the landowner or the farmer but "exclusively in the national interest"; that the policy advocated must stand or fall as a whole; that attempts to apply it piecemeal are doomed to failure—albeit development of the policy must be a gradual matter, extending over a long period of years.

The three principles of a guaranteed price for wheat and oats, to secure stability of conditions for all who live from the land, a minimum wage to secure a fair share of the profits of agriculture to the labourer, and a power in reserve which the State may use to secure the greatest national advantage, are embodied in the Corn Production Act. That Act is temporary, but the three principles must be embodied in after-the-war legislation, contend the Committee, as the permanent basis for agricultural reconstruction. Unless they are so embodied, "there can be no hope for the people of the United Kingdom becoming emancipated from dependence on supplies of food brought from overseas or of the increase of our rural population."

Taken alone, these three principles, however, will not suffice. Parts I. and II. of the Report "are not separable." The measures they recommend are "strictly interdependent and mutually essential parts of one policy. Without the aid of the measures recommended in Part II. the stability of the industry of agriculture and the authority of the State secured by Part I. can only produce partial results.

Food Growing and National Security.

"We have been asked," says the Committee, "how great an increase of our home-grown food supply is necessary in the interests of national security, and how great an increase is possible. Our reply is that in any future crisis like the present war this country must be wholly independent of oversea supplies of corn, potatoes, or dairy produce, and that it must be less dependent on overseas supplies of meat than it is now, and that, if the measures we recommend are continuously carried out, the dependence of this country on overseas supplies of food will become continuously less during the years of peace, with the result that on the outbreak of war, and by carrying out the plans of the Board of Agriculture carefully matured in times of peace specifying the crops to be grown, the country would become self-sufficient in the foodstuffs named after the first subsequent harvest in respect of the cultivation for which these plans had been carried out. With sufficient land under the plough and in good heart this is a perfectly practicable policy. Without a sufficient increase of arable land it is not practicable.

"To cover the interval before the first harvest it would be a wise completion of the policy of insurance to have a store of grain in national granaries. But it may be urged, would it not be a better and simpler plan to rely on national granaries altogether, and not to attempt the policy of the plough? The answer is that it would cost more to establish national granaries to supply the United Kingdom during a three or four years' war than the policy we recommend will cost, and that sole reliance on a granary policy would not only bring with it no increase of the rural population but a certain further diminution, resulting from the certain further conversion of millions of acres from arable to grass."

Agriculture or Industry or Both?

A spirited counter-attack is made by the Committee upon the criticism with which the policy of Part I. of the Report was assailed when the Corn Production Act was under discussion. This criticism, which aimed at proving that our country is pre-eminently fitted for an industrial system and climatically unfitted for an agricultural system, and that agriculture can only be developed at the expense of British manufactures and the British mercantile marine, is commented upon as follows:—"It wholly ignores the value to a nation of mixed rural and urban population. It denies any place to agriculture in the national life. It is based on supposed considerations of national wealth only. Carried to its logical conclusion, it would degrade the use of English land to the perpetual sport of the manufacturing rich, and to the occasional playground of the poor.

"And why stop there? If it is right to keep the production of home-grown corn down to the lowest possible point in order that the mercantile marine may have the greatest possible number of wheat cargoes to bring home, why not reduce the production of home-hewn coal to the lowest possible point, and so open up a vast new carrying trade for our shipping? The fact is that the argument is as wholly unsound economically as it is socially *The great development of German agriculture, which has enabled the German Empire to sustain the war for three*

years, exactly synchronised with the equally great development of German manufactures and of the German mercantile marine. It has also synchronised with an immense increase of the German population and an almost complete cessation of German emigration. Why should our experience be different?

"It would, indeed, be a deplorable dilemma if we had to choose between the prosperity of agriculture, manufactures, and shipping, if their interests were in fact mutually antagonistic. But the exact contrary is the case. The greater the production of our soil the greater the home market for our manufactures, and the greater the demand for overseas goods which our country cannot supply. No one would suggest that a great addition to our national wealth in any other form than agricultural products, such as the discovery of great oil wells in the United Kingdom, could possibly in the result be bad for our national manufactures or our national trade and shipping. Why, therefore, should it be bad because the form which the increase in national wealth has taken has been the extraction from our native soil of a much greater bulk of foodstuffs than hitherto? If the investment by the nation in agriculture of the comparatively small sum we suggest results in the production in this country of a large proportion of that £200,000,000 (or a vastly larger sum at war prices) worth of foodstuffs annually imported before the war, will that be a bad commercial proposition for the nation?"

Proposed Reforms.

The Committee proposes that its policy should be carried out with a reorganisation of the agricultural administration of the country, which includes *inter alia* the setting up of National Agricultural Councils in the four countries (delegates from which would meet annually), and of statutory County Agricultural Committees; also the appointment of a Minister of Agriculture for Scotland.

On the subject of agricultural Instruction and Research, the Committee recommends that responsibility for agricultural education should be removed from the County Councils and centralised in the Board of Agriculture; that an improved ruralised curriculum for elementary and secondary schools should be laid down and better prospects provided for teachers; that demonstration farms should be established, a limited number of them to be large farms run on business lines, and that better opportunities should be given for the agricultural education of women.

To promote agricultural organisation and co-operation, the Committee recommends that additional support from national funds should be given to existing societies. To provide credit for agriculture, they urge that the procedure in respect of loans guaranteed by the Board of Agriculture should be cheapened and simplified, and that short term credit through co-operative trading societies and Farmers Central Trading Boards should be provided. Deposits in the Post Office Savings Bank, they consider, should be made available for use by the Central Trading Boards.

Land for Small Holders.

The Committee considers that greater facilities for purchase should be given to small-holders; that the County Councils should be urged to prepare schemes at once for the provision of small-holdings for ex-soldiers and sailors, both as tenants and as owners, and that the Treasury should remove the financial restrictions now placed upon the Councils. They think that the principle of purchase contained in Mr. Jesse Collings' Purchase of Land Bill should be adopted, giving small-holders a right of purchase, such as exists in Ireland.

The Committee regards Village Reconstruction as an important part in the furtherance of its policy, and considers that the development of rural industries and the formation of women's institutes should be helped forward. To make land more available for small-holders and for village reconstruction, they recommend legislation to stimulate tithe redemption. As to local taxation, they consider that the cost of national services should be more equitably divided between local and national funds.

A number of alterations of the Agricultural Holdings Act are recommended, especially in questions of compensation. Land reclamation and drainage, it is urged, should be dealt with in a thorough and comprehensive manner by legislation. Reclamation and drainage authorities for each of the three kingdoms should be established. Deer forests on lands suitable for agriculture and forestry should be used for these purposes, and a special survey should be made to ascertain what deer forests can be so used. The restoration of sheep farms should be gradually accomplished by the extension of existing stocks. The question of wintering stocks of store cattle in some of the forest areas should be thoroughly gone into.

Weeds and Animal Pests.

The Committee points out that no systematic attempt has yet been made in Great Britain to deal with animal pests such as rabbits, rats, and sparrows, or with plant weeds, and that we are behind some of the Dominions and some foreign countries in this respect. They recommend legislation to prohibit the sale of grass and clover seeds without a guarantee of purity, and to penalise negligent farmers who allow weeds to flourish. Similar action is recommended in the case of animal pests. Steps should be taken by urban authorities to put down rats, which escape from the towns, especially sea ports, to the adjoining country areas.

The Committee contends that British agriculture has suffered owing to the extraordinary diversity of weights and measures applying in different parts of the country. Three systems of weights and measures have legal authority in the United Kingdom, and in addition there are local measures to be found in almost every county. The result is confusion, detrimental to the industry. The Committee recommends a uniform standard of weights and measures to come into force after a fixed period of transition.

Rural Transport.

Reorganisation of rural transport is regarded by the Committee as an essential feature of agricultural reconstruction, and the whole question is dealt with at some length in one of the appendices to the report. The Committee recommends that farmers should be induced to act in co-operation to transport more of their materials and produce by water, and that a scheme should be prepared to apply discarded Army motors for rural transport and other farm purposes. They also recommend the application of public funds to assist in the organisation of motor transport. Referring to existing anomalies in railway and other transport charges, the Committee express the view that to charge rates for foreign produce lower in proportion to the cost of the services rendered than the corresponding rates for home produce should be looked upon as preferential treatment, and that the Government should take the steps necessary to enforce the law as to undue preference.

The report is available from H.M. Stationery Office, Imperial House, Kingsway.

Catalogue of Scientific Books.—Messrs. Henry Sotheran and Co., 140, Strand, W.C. 2, have recently issued a catalogue which is well worth the attention of scientific men and book buyers. It contains lists of the scientific portion of the library of the late Rt. Hon. Sir James Stirling, F.R.S., and selections from those of George Rennie, C.E., F.R.S., and Samuel Roberts, F.R.S., and many bargains are to be found mentioned in its pages. The notes on the contents of important books and rare editions are useful and interesting, and sometimes refreshingly outspoken. The price of the catalogue is 2s. 6d.

ORDER OF THE MINISTRY OF MUNITIONS.

GAS WORKS.

THE Minister of Munitions, in exercise of the powers conferred upon him by Regulation 8Q of the Defence of the Realm Regulations, and of all other powers enabling him, hereby orders as follows:—

1. This Order shall apply to all Gas Works throughout the United Kingdom, excepting only Gas Works which possess coal gas plants only and have no plant installed for scrubbing or washing their gas either with oil or with tar.

2. As on and from July 1, 1918, the manufacture and production of gas in all gas works to which this Order applies shall be carried out in accordance with the general regulations set out in the schedule hereto, save and except only if and so far as such general regulations may in the case of any particular Gas Works be varied or superseded by any special directions or regulations given or made from time to time with regard to such Gas Works by or under the authority of the Minister of Munitions.

3. This Order may be cited as the "Gas Works (Ministry of Munitions) Order, 1918," and the regulations set out in the schedule hereto as the "Gas Works (Ministry of Munitions) General Regulations, 1918."

NOTE.—All applications with reference to this Order or under or with reference to the General Regulations set out in the schedule hereto should be addressed to the *Ministry of Munitions, Department of Explosives Supply*, Storey's Gate, S.W. 1, and marked "E. G. S.."

General Regulations.

1. Gas Works which have coal gas plants only shall work such plants so as to produce gas of a calorific power of as nearly as possible 500 B.Th.U. gross, but not in any event less than that calorific value, before scrubbing as mentioned in Regulation 3 below.

2. Gas Works which have both coal gas and water gas plants shall work such plants so as to produce a gas of the calorific value specified in Regulation 1 above. Gas of the required calorific value may be produced either by working the coal gas plant alone so as to produce a gas which (before scrubbing in the case of works having scrubbing facilities) is of the required calorific value, or by working the coal gas plant so as to produce gas of a higher calorific value, and subsequently mixing with the same such a quantity of uncarburetted water gas as, apart from any reduction in the calorific value of the coal gas produced by scrubbing, would produce a mixed gas of the required calorific value.

3. All Gas Works which have facilities for scrubbing their coal gas shall scrub the whole of the coal gas produced at such works to the fullest possible extent for the extraction of ammonia, toluol, and benzol. Scrubbing for toluol and benzol shall be effected with oil, at works where there is a benzol recovery plant, and, at other works, with tar.

4. If at any time it is impossible for any Gas Works to supply the full demands of its consumers for gas, whilst complying with the above regulations, notwithstanding that it is working its coal gas plant to its full capacity, then—

(a) If such gas works has a water gas plant, the balance of its consumers' requirements shall be made by an admixture or further admixture of uncarburetted water gas, but so that the calorific value of the mixed gas, as actually delivered to its consumers, shall be maintained as high as possible, with a minimum, under all circumstances, of 450 B.Th.U. gross. Should this be impossible without carburetting the water gas, the water gas shall be carburetted with gas oil so as to bring the mixed gas up to the minimum calorific value specified above, and such gas works shall take forthwith all possible steps for obtaining the gas oil required for the purpose.

(b) If such gas works has no water gas plant, it must notify the Minister of Munitions forthwith of its inability to supply its consumers' full demands, reporting in detail all the circumstances which render it impossible for it to do so, and must comply with any instructions or directions which may be given by or under the authority of the Minister of Munitions after consultation with the Board of Trade as to the steps to be taken by it in the circumstances.

5. Excepting only as provided in Regulation 4 (a) above no gas works shall in any circumstances use any gas oil for carburetting its water gas (whether before or after admixture with its coal gas) without the previous authority in writing of the Minister of Munitions or his duly authorised representative.

RECONSTRUCTION IN INDUSTRY.

PROGRESS IN THE FORMATION OF WHITLEY COUNCILS.

THE formation of Joint Industrial Councils on the lines of the Whitley Report is steadily progressing. Councils in the Pottery and Building Industries are already at work, and during the present month the following newly formed Councils will hold their first meetings:—

- The Heavy Chemical Trade.
- Gold, Silver, and Allied Trades.
- The Rubber Industry.
- Match Manufacture.
- The Silk Industry.

The dates of the Meetings have been fixed in the case of the Rubber Council which takes place on July 16, Gold, Silver, and Allied Trades Council on July 20, the Matches Industrial Council on July 30, and the Silk Industrial Council which takes place on either July 25 or 30.

In the following industries provisional Committees have already drafted Constitutions of proposed Industrial Councils which have been sent out to the various Associations concerned for their approval:—

- Baking.
- Cable Making.
- Commercial Road Transport.
- Electrical Contracting.
- Furniture Making.
- Leather Goods and Belting.
- Vehicle Building.

A Constitution for the Printing Industry has been drafted and will shortly be sent out for approval to the Associations concerned. When these constitutions have been approved the first meetings of the newly-formed Councils will be arranged with as little delay as possible.

In the following industries preliminary conferences as to the formation of Industrial Councils have taken place and proposals to proceed with the drafting of Constitutions have been approved:—

- Bobbin Manufacture.
- Boot and Shoe Manufacture.
- Electricity Power and Supply.
- Roller Engraving.
- Woollen and Worsted Industry.

In some twenty other Industries the question of the formation of Joint Industrial Councils is being given careful consideration, and in a number of cases proposals to summon joint conferences of Employers' Association representatives and Trade Union representatives have been approved.

There are many of the Nation's industries of course in which the organisation on the side either of the employers or of the workers is not sufficiently representative as yet to admit of the formation of Joint Industrial Councils at once. In these industries the "Whitley Idea" is being carried out by the formation of temporary bodies which are termed Interim Industrial Reconstruction Committees.

They will deal with the many urgent problems attached to the re-establishment of their representative industries on a peace basis, and in addition will improve the organisation of their trades where it is at present unrepresentative. Later it is hoped they will be in a position to pass from their temporary nature and become full Joint Industrial Councils. (Towards the formation of these temporary bodies the Ministry of Reconstruction has already made considerable progress, and Committees have already been established in some twenty trades and industries. Fuller details of progress in this matter will be available shortly).

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, June 6, 1918.

Sir J. J. Thomson, O.M., President, in the Chair.

The following paper was read:—

"*Brevity, Frequence of Rhythm, and Amount of Reflex Nervous Discharge as Indicated by Reflex Contraction.*" By N. B. Dreyer and Prof. C. S. Sherrington, F.R.S.

A single momentary stimulus of moderate intensity, *e.g.*, a break-shock, even though not far above threshold value of stimulation, applied to the afferent nerve of a spinal reflex-centre, evokes from that centre not uncommonly a repetitive series of volleys of motor impulses.

It tends to do so more as the stimulus, within limits, is increased in intensity, but the state of the reflex-centre at the time is also a decisive factor.

The rhythm of repetition of volley-discharges from the spinal reflex-centre was traced, by the ordinary mechanical method, to be of synchronous rate with that of stimulation of the afferent nerve, up to a frequence of 55 per sec., and by a mechanical resonance method up to a frequence of 65 per sec.

By a "doubling frequency" method it was shown further that the frequence-rate of the reflex discharge has not reached its limit under a stimulation of 75 per sec., but surpasses that degree, though by what amount the method cannot say.

The maximal mechanical power of a muscle contracting under spinal reflex action is frequently as great as the maximal which can be evoked from it by direct faradisation of the motor nerve itself.

Ordinary Meeting, June 13, 1918.

Sir J. J. Thomson, O.M., President, in the Chair.

Papers were read as follows:—

"*Experiments on the Effect of the Vibration of a Stretched Wire Forming Part of a Closed Electric Circuit.*" By Admiral Sir Henry Jackson, G.C.B., F.R.S.

A large thermo-microphone consisting of a long loop of wire warmed by an electric current, subjected to vibration produced by sound waves, continued to respond to and record the effect of the vibration in suitable receiving apparatus, after the electric battery had been cut out of its circuit, and when the wire was at the same temperature as the air. This result of the wire's vibration could not therefore be solely attributed to the wire being maintained at a different temperature to that of the surrounding air by an electric current in it.

The response to the sound and other vibrations was generally recorded by means of an amplifier and telephones. Experiments were carried out to elucidate the cause of the phenomenon.

The paper first deals with the types of wires tested and the precautions necessary to eliminate errors. Varying the angle of the wire with line of the earth's magnetic force produced entirely negative results. Wires of various materials and of lengths up to 220 feet (the longest tested), stretched and subjected to forced vibrations, almost invariably generate a current of electricity in the circuit of sufficient intensity to be audible in a suitable telephonic receiver, with or without an added E.M.F., in the circuit. The addition of a valve amplifier greatly increases the intensity of the sound, and has enabled more complete conclusions to be drawn, as to the varying response of different wires and the form in which they are stretched, than would have been possible without such an instrument.

The form in which the wires were stretched is described. It is shown that resonance plays an important part. No definite conclusions, however, can yet be drawn as to the quantitative effect of altering tension or length of wires, or their displacement, on current generated, nor does the energy expended in producing vibration appear to be proportional to the effect produced, except resonance is present.

"*Effect of Wind Pressure on the Pitch of Organ Pipes.*" By A. Mallock, F.R.S.

The fact that the pitch of an organ pipe is to some extent dependent on the pressure of the wind supply is well known, but no satisfactory explanation of this dependence has hitherto been offered.

In the present note some experiments on the subject are described in which water instead of air was used as the oscillating fluid. It is shown by photography that the lateral motion of the fluid jet or lamina which maintains the oscillation is always in the direction of the oscillating flow, and also that the oscillation is not (or only very feebly) maintained unless the jet breaks up into eddies before striking the "lip" of the pipe.

It is suggested that the rise of pitch which occurs when the jet velocity is increased depends on the jet acting as an injector. Part of the fluid belonging to the oscillating flow becomes involved in the eddies of the jet and is accelerated by energy drawn from this source, thus diminishing the amount of energy which would otherwise have to be taken from the oscillating system.

In effect this action reduces the oscillating mass, and thereby increases the frequency.

The results obtained with the water oscillator are compared with Lord Rayleigh's experiments on organ pipes, and it appears that the variation of frequency with the pressure of the fluid supply is similar in type in both cases.

"*The Diamagnetism of Hydrogen and the Value of the Magneton.*" By A. E. Oxley, D.Sc.

PHYSICAL SOCIETY.

Ordinary Meeting, June 14, 1918.

Prof. C. H. Lees, F.R.S., President, in the Chair.

A discussion took place on "*The Teaching of Physics in Schools.*"

Sir Oliver Lodge, who opened the discussion, said it was desirable that the ordinary man should know more about physics than was the case at present. The teaching of science in school was a difficult matter. There were many methods, possibly many good methods, provided the essential enthusiasm for the subject was present. To teach the subject to scholars with a view to later specialisation was easier than to make it part of a general education. You have to interest them in the subject, and avoid making it repulsive, covering a wide ground without too much detail. For children the synthetic method was preferable to the analytic—*i.e.*, you must begin with principles and build up rather than start with the so-called "common object" and analyse into principles. Most common objects involve too many principles and too much mathematics. Many teachers overdo the measurement of things. It is the things themselves that are

really of interest to scholars. For the majority of children we must make science one of the Humanities.

Prof. A. Gregory said that about thirty years ago the Association of Headmasters evolved a system of science teaching, the main feature of which was quantity rather than quality. This had been generally adopted, and the result was that the vast majority of boys on leaving school knew nothing beyond how to make a few more or less precise measurements of specific heat, &c., and are ignorant of the elements of such everyday things as electric bells. A laboratory course should be associated with descriptive lessons, which should be as independent of it as possible. Teachers should consider whether or not it is possible in association with a Society like this to formulate a course suitable for the needs of the ordinary boy and girl.

Mr. C. L. Bryant said the importance of science in general education was that it inspired the search for truth based on evidence rather than on authority, and illustrated the laws of cause and effect. In his experience boys did not want to know the principles of science. They were interested in motors or steam-engines, but not in the details of steam pressure. He thought that they learnt more readily from the machine than from a study of principles. The worst fault in the teaching of science in schools was the neglect of mechanics. The traditional character of examinations greatly hampered teachers.

Dr. T. J. Baker said that an important consideration in dealing with this question was that of age. The conditions of work at a university were so different from those at a school that a boy of sixteen must be very advanced indeed to profit by a university course. Boys up to eighteen were better at school. He circulated a syllabus of the maximum that should be expected from boys of eighteen who had been specialising for one to two years. He emphasised the difficulties due to the want of knowledge of mechanics.

Dr. F. W. Sanderson, in a telegram apologising for absence, suggested the appointment of a small committee to consider the matter.

Mr. C. E. Ashford described the aims and procedure of the science teaching at the Royal Colleges of Osborne and Dartmouth. The course in physics begins with an unsystematic treatment of hydrostatics, and work begins at once in the laboratories and engineering workshops. The effect of the rapid alternation of theory and actual practice was favourable to both, not least in the case of young boys. Workshop practice makes demands on the recently acquired stock of knowledge, and stimulates interest in theoretical work. The comprehension of mechanical principles seemed to be a function of age; the commencement of physics cannot wait for the attainment of that age, and many masters successfully attempt the early stages of physics without depending on mechanics.

Mr. A. T. Simmons said that hitherto school courses of physics had been designed on the assumption that school work is only preliminary to a fuller university course. This, however, only applies to a small fraction of the pupils, and the teaching of physics in schools will only be satisfactory when it is recognised that the course must be complete in itself. What should be decided therefore was what parts of physics should be known by every educated citizen, and what steps should be taken to make it easy for the secondary school pupil to acquire this knowledge at school. He deprecated the common habit of beginning laboratory practice with dry-as-dust measurements of length, areas, value of π, &c., which sickened the beginner. The use of the laboratory should begin where water and the balance are necessary.

Prof. F. Womack said his outlook on the subject was probably somewhat narrower than that of the other speakers, as the students he had to deal with were men going in for medicine and women going in for teaching. They entered at seventeen and a-half or eighteen years, and for some years he had taken statistics of the knowledge which they possessed on entering. In the last few years 34 per cent had no knowledge whatever of physics. Classics appeared to predominate in the curriculum of most schools, and a boy who went in for science was regarded as of inferior intellect. Science should be treated from the physical side, and should not be handled by the mathematical master. He approved of Sir O. Lodge's suggestion that the study should be made as humanistic as possible. It would probably be a gain to avoid a cut-and-dry syllabus in the early stages, leaving room for the initiative and judgment of the teacher.

Mr. J. Nicol said that science teaching of the best type should satisfy and stimulate the interest of the boy, when it would frequently create an interest in scientific progress, the pursuit of which will serve as an intellectual recreation through life. Too much time is spent on laboratory exercises, which yield definite numerical results, because of the ease of checking and assessing marks. Other parts of the subject, though equally important, tend to be neglected. There ought to be lectures of a general character illustrated by qualitative experiments and lantern slides showing the application of science to everyday life.

Mr. E. Smith showed lantern slides of a design for a school laboratory suited for the rapid alternation of lecture and laboratory work, in order that short experiments may be interspersed with explanation and discussion.

Mr. F. B. Stead thought that much of the alarming uniformity that had been mentioned by speakers was due to the influence of conditions, such as the general traditions of teachers, examiners, &c., and last, but not least, to text-books. He agreed that the preliminary mensuration work should be done by the mathematics teacher. There was a tendency for measurements to be regarded as an end in themselves. It was more important that a boy should know that there were such things as specific heat and latent heat and their bearing on everyday phenomena, such as the effect of sunshine on land, than that he should begin by measuring those quantities in the case of copper or ice. Attention had been directed to two methods of teaching—one deducing the principles from the machine, and the other explaining the machine from the principles. These in theory were diametrically opposed, but he thought that in practice they would very frequently be found in combination to a greater or less extent.

Sir O. Lodge, in closing the discussion, said the main point of difference between his own views and those expressed by any of the speakers was whether the synthetic or analytical method were preferable. It was possible, as suggested by the last speaker, that the difference was not so great in practice as in theory, but he would nevertheless expect any systematic course to begin with principles. It was no doubt the machine itself in which the pupil was interested, but the problem was how to get the principles out of the machine.

CHEMICAL SOCIETY.

Ordinary Meeting, June 6, 1918.

Prof. W. J. Pope, C.B.E., F.R.S., President, in the Chair.

It was announced that the Society has lost, through death, the following Fellows:—Walter Augustus Handcock, Henry Tylston Hodgson, and Mulgrave Daniel Penney.

Messrs. A. Geake, K. G. Laiwala, and R. Brightman were formally admitted as Fellows of the Chemical Society.

Certificates for election were read for the first time in favour of Frank Bainbridge, Woodland View, West Road, Loftus-in-Cleveland; Reginald Percy Leopold Britton, 58, The Crescent, Wimbledon Park, S.W. 19; John Edwyn Davies, B.Sc., Taimawr, Swansea Road, Merthyr Tydvil; Campbell Falconer, The Hall, Osbaldwick, York; Bernard Arthur James Jeffs, 35B, Gladstone Avenue, Wood Green, N 22; Edwin Percy Keeble, Summer Lodge, Kenilworth; Albert Victor Mountford, 38,

Gamblins Road, St. Martin's, Christchurch, New Zealand; Frederick Gerald Tryhorn, M.Sc., 45, Halliville Road, Mossley Hill, Liverpool; Gerald Noel White, B.Sc., 15, West End Avenue, Pinner, Middlesex; John William Reginald Youll, "Keswick," Rainsford Avenue, Chelmsford.

Dr. HORACE T. BROWN then delivered his lecture, entitled "The Principles of Diffusion—their Analogies and Applications."

A vote of thanks to Dr. Horace T. Brown for his lecture, proposed by Prof. P. F. FRANKLAND and seconded by Prof. FARMER was carried with acclamation.

Ordinary Meeting, June 20, 1918.

Mr. A. CHASTON CHAPMAN in the Chair.

It was stated that the following Fellows had died:—Thomas Farries and Alexander Milne.

The following announcements were made:—

1. That a communication had been received from the Committee of the van 't Hoff Fund for the endowment of research in pure and applied chemistry. (See p. 236).

2. The Council have decided to issue the list of Fellows in the near future; it will not be circulated in the usual manner, but may be procured by Fellows on applying to the Assistant Secretary.

3. In view of the shortage of paper, the Council wish to emphasise the necessity of authors reducing as far as possible the length of scientific communications submitted to the Society.

4. The Council have appointed a Committee, consisting of the following, Messrs. W. R. Bousfield, A. G. Green, C. A. Hill, G. T. Morgan, A. Scott, and W. P. Wynne, and the Officers, namely, Messrs. W. J. Pope, M. O. Forster, S. Smiles, J. C. Philip, and A. W. Crossley, to consider the revision of the by-laws. Opportunity will be afforded to Fellows for bringing forward suggestions on the matter.

Certificates of candidates for election were read for the first time in favour of Claud Diamond, B.Sc., 17, Moresby Road, Upper Clapton, E. 5; John Edward Doodson, Smithy Bridge, Rochdale; John Robert Douglas, A.R.C.S.I., West-field, Saltcoats, B.O., Ayrshire; Laurence Francis Le Brocq, B.Sc., "Akender," Guildford Road, South Farnborough, Hants; Donald Neil McArthur, B.Sc., 28, Grafton Street, Glasgow; George Frederick Robertshaw, Mornay, Kearsley Road, Higher Crumpsall, Manchester; Eric Sinkinson, 14A, Albert Bridge Road, S.W. 11; Thomas Rinck Stopford, M.Sc., "Woodbank," Macclesfield.

Certificates for election have been authorised by the Council for presentation to ballot under By-law I. (3) in favour of James Garfield Anderson, M.Sc., Southland Boys' High School, Invercargill, New Zealand; Juan Pedige Charles Chandrasena, B.Sc., Technical Schools, Colombo, Ceylon.

Messrs. F. H. Lowe and J. Reilly were elected Scrutators, and a ballot for the election of Fellows was held. The following were subsequently declared duly elected as Fellows:—William Baird; George Henry Rowland Barham; Joseph Gauld Bearn, M.Sc.; Joseph William Bell; George Rowland Bolsover; Henry Aldous Bromley; Albert Eric Cashmore; Roland Lebeg Townley Clarkson; John William Cobb; Hubert William Dailey; Thomas William Derrington; George William Dunster; Arthur Broughton Edge; Stanley Elliott, B.Sc.; Robert Ellison; Francis William Fitzgerald; Sidney Fleminger; Frank Scott Fowweather, M.Sc.; Stanley Joseph Green, B.A.; Nalini Mohan Gupta, M.Sc.; Ernst Johannes Hartung, M.Sc.; Fred Henesey, B.Sc.; John Bright Hoblyn; John Laurence Pitchforth Hollingworth; James Henry Lindfield; Ben Lockspeiser, M.A.; Francis John McConnell; Alfred Zygmunt Molteni; Edgar Newbery, D.Sc.; Edward Churton Powell; Madyar Gopal Rau, M.A.; Bertram Leonard Read, B.Sc.; Runar Ivar Olsson Seffer Alan Speedy; Louis Stott; John Thomas, B.A., D.Sc.; John Turnbull; Richard Henry Vernon, Ph.D.; Hubert Charles Siegfried de Whalley; William Whyte; Samuel Walter Woolley.

The following papers were read:—

"The Equilibrium Isotherm of Association in Organic Solutions the Solvent of which is Unassociated as Pure Liquid." By W. R. INNES.

"Diazoimides of Nitro- and 2·6 Dichloro *p* phenylenediamine." By G. T. MORGAN and D. A. CLEAGE.

NOTICES OF BOOKS

Helvetica Chimica Acta. Basel and Genève: Georg and Co.

NOWADAYS, when the ardent prosecution of pure research for the purpose of the advancement of natural knowledge is at a low ebb in all combatant countries, the appearance of the first number of *Helvetica Chimica Acta*, the official organ of the Swiss Chemical Society, is certain of a hearty welcome on the part of British chemists. It is true that the multiplication of chemical journals which has been pronounced during the past thirty years or so has been looked upon askance in many quarters; but when the large output of research in borderland subjects, in bio-chemistry, for instance, is borne in mind, it will be pretty generally admitted that these new journals have, on the whole, thoroughly justified their inception. Whether this be the case or not, the recent decision of the Chemical Society of Switzerland to found a journal of its own is readily understood. The President, Prof. Guye, makes it clear in his preface to the new journal that the demand for a separate organ of this kind was imperative. The demand was indeed a national one. It was unanimously adopted at a general meeting of the Society held in Zürich in September, 1917, and is an index of the spirit of independence which is so characteristic of the Swiss character.

One wonders why this advance has been delayed for so long, and that Swiss chemists have for so many years been content to publish much of their best work in the columns of foreign periodicals. This anomaly now terminates, let us trust for all time.

The new journal will contain papers published in French, German, or Italian, and the intention is that it will give an account of the contributions to chemical research made by Swiss chemists resident either at home or abroad. The amount of research emanating from the universities and the technical high schools of Switzerland is large and greatly to the credit of these institutions; before 1914 no less than about 380 separate publications on chemical topics were made annually, and many of these were of supreme interest. The Publication Committee of the new journal is a particularly strong one, and inspires confidence, consisting as it does of six chemists who command respect as investigators, namely, Guye and Pictet (from Geneva), Fichter and Rupe (from Bâle), and Bosshard and Werner (from Zürich). The interests of the journal will assuredly be safe in the hands of these men.

It is proposed that, as a start, from six to eight numbers be published annually. The opening papers set a high standard. In the paper by Werner, entitled "Ueber eine neue Isomerieart bei Kobaltverbindungen und Verbindungen mit Asymmetrischem Kobalt und Kohlenstoff," we are presented with a notable contribution to our knowledge of cobalt compounds displaying molecular asymmetry, a field which Werner has recently originated and developed with such remarkable ingenuity. Then comes an important study of Guye and Schneider, "Réduction des Oxydes d'Azote en Ammoniaque; Stabilité du Bioxyde d'Azote," which will demand the close attention of all chemists who are interested in the conversion of atmospheric nitrogen into ammonia. Other papers are:—"Ueber das Vorkommen von Selenwasserstoff im Regen und im Schnee," by Th. Gassmann; "Ueber Nitrosopentamminkobaltisalze," by A. Werner and P. Karrer;

"Zur Konstitution der inneren Metallikomplexsalze," by A. Werner and Soph. Matissen; "Détermination de la Tension Superficielle et de la Densité Critique de l'Ammoniaque," by A. Berthoud; "Sur la Distillation de la Cellulose et de l'Amidon sous Pression réduite," by A. Pictet and J. Sarasin.

Very gratifying is the announcement made by Prof. Guye that the creation of *Helvetica Chimica Acta* has been rendered possible by the generous liberality of the Swiss chemical industry. No fewer than twenty-two of the leading Swiss firms have subscribed the *total* capital necessary to guarantee the success of the new undertaking. With this strong financial backing the future of the journal is assured. The hope may be expressed here that this wise policy on the part of Swiss industrial concerns will not escape the notice of the wealthy chemical manufacturers of this country. The Chemical Society, which is the mother of all chemical societies, has never in the course of its long history received support such as the above.

The price (to non-members) is 25 frs. per annum.

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Vice-Principal: E. M. Wrong, M.A. (Fellow Magdalen Coll., Oxf'd).

The Session 1918-1919 will open on 3rd October. Matriculation and Entrance Examinations will be held in July and September. Matriculated students may enrol for 1918-19 from 1st August, 1918, and if under 18 years of age are eligible for membership of the Officers' Training Corps.

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THE CHEMICAL NEWS.

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THE recent paper restrictions have compelled us to publish only fortnightly instead of weekly for a time, but we are now glad to be able to announce that we are to be allowed a further supply of paper, which will enable us to revert to weekly publication in the near future.

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ON SPINACENE AND SOME OF ITS DERIVATIVES.*

By A. CHASTON CHAPMAN.

IN a recent communication (*Trans.*, 1917, cxi., 56) describing the preparation and properties of spinacene and of some of its derivatives, I directed attention to the fact that the formula for the hydrocarbon based on the analysis of the hexahydrochloride (which was the most crystalline and best defined compound I had succeeded in obtaining) was not in good agreement with the results for the determination of the molecular weight by the cryoscopic method. This discrepancy I was unable to explain, and I therefore determined to prepare a further and larger quantity of the hydrocarbon and also of the hydrochloride. I was fortunately able to obtain some more of the shark-liver oil, and proceeded to prepare spinacene from it by the method previously adopted. As in my earlier work, the main fraction boiled within a range of a few degrees and contained only about 0·5 per cent of oxygen.

As I had reason to believe that metallic sodium was without action on the hydrocarbon, I proceeded to distil it with the addition of some sodium for the purpose of obtaining a product free from oxygen. In my earlier work only about 50 cc. of the oil had been distilled in this manner, and then under a pressure of 10 mm. In the present case a much larger volume of the oil was employed, and owing to the faulty working of the pump the pressure during distillation remained constant at about 45 mm., the bulk of the oil distilling under that pressure at about 290°. It was noted that during the distillation the liquid in the flask became increasingly dark in colour, and towards the end had become converted into an almost black tarry mass.

The portion of the oil, which had distilled over between 280° and 295°, was then submitted to fractional distillation (without sodium) at a pressure varying from 35 to 40 mm., and it was found that the boiling-point rose gradually from 84° to 298°.

* From the *Transactions of the Chemical Society*, 1918, vol. cxiii.

From this result it is evident that in the presence of sodium and under the conditions above mentioned, spinacene undergoes some decomposition, and that this method cannot consequently be adopted for its purification. I therefore decided to prepare some more of the spinacene by fractional distillation without the use of sodium and at a pressure not exceeding 10 mm. In these circumstances a large specimen of the hydrocarbon was obtained having the following properties:—

Boiling-point..	260° (corr.)/9 mm.
Specific gravity (15°/15°) ..	0·8610
Refractive index at 20° . ..	1·4956

When examined by the Wijs method it was found that 100 parts of the hydrocarbon united with 367·9 parts of iodine.

The following molecular weight determinations were made by the cryoscopic method:—

I. 0·2262 in 16·83 benzene gave $\Delta t = -0·167°$; M.W. = 394.
II. 0·2371 in 17·07 benzene gave $\Delta t = -0·174°$; M.W. = 391.

This number is higher than that given in my previous paper, and in view of the results obtained in the distillation of this larger quantity of hydrocarbon the discrepancy is readily explained. Although the breaking up of spinacene when distilled over sodium does not appear to take place at all rapidly until a temperature corresponding with a pressure of about 40 to 50 mm. is reached, there can be no doubt that a little decomposition does occur even at lower temperatures, and that the hydrocarbon which I originally used for the molecular weight determinations must have been contaminated with a little of the decomposition products of lower boiling-point.

It may be recalled that the average results of five analyses of the hydrocarbon given in my previous paper were as follows:—C = 87·75; H = 12·45.

The above results therefore agree well with the formula $C_{29}H_{48}$, which requires C = 87·88; H = 12·12 per cent; M.W. = 396.

Taking the previously determined number for the specific refraction, namely, 0·3394, the molecular refraction is 134·4 Employing Conrady's average numbers for the atomic specific refractions (D-line), $C_{29}H_{48}$ with six ethenoid linkings requires 134·3. Taking the specific dispersive power of spinacene as 0·0114 its molecular dispersion $(r\gamma - r\alpha)$M, is 4·51. Taking Eisenlohr's numbers for the atomic dispersion for the α- and γ-hydrogen lines the calculated number is 4·21.

As the results of the analysis of the hexahydrochloride which I had previously prepared were in fair agreement with the higher formula, $C_{30}H_{50}$, I determined to prepare a larger quantity of this compound and to submit it to a very thorough process of purification. It was prepared as before, by passing dry hydrogen chloride into a well cooled solution of spinacene in dry ether. The resulting hexahydrochloride was then purified by dissolving it in warm benzene and adding alcohol until the compound commenced to separate, and finally by crystallising from warm benzene alone. Chlorine estimations were made in each crop of crystals, and the process of recrystallisation was repeated until the chlorine percentage, which showed a tendency to increase, became constant. After the third recrystallisation the substance was analysed, with the following results:—

0·2020 gave 0·2814 AgCl; Cl = 34·45.
0·2145 gave 0·2990 AgCl; Cl = 34·49.
$C_{29}H_{48}$,6HCl requires Cl = 34·60 per cent.

In the process of recrystallisation the melting-point also rose, the final preparation becoming pasty at about 120° and melting to a clear liquid at 126°. During this process of recrystallisation a small quantity of an oily substance containing about 24 per cent of chlorine was separated from the mother-liquors. It will be seen that the above result is in far better agreement with the formula $C_{29}H_{48}$

than with the formula previously suggested, namely, $C_{30}H_{50}$, which requires Cl = 33·86 per cent. A 5 per cent solution of the hydrochloride in benzene was found to be optically inactive.

When heated for some time with boiling water, in which it appears to be quite insoluble, no decomposition occurred. When heated, however, for some time with a mixture of alcohol and water, the crystals soon became pasty, and the liquid, after filtering, gave a strong reaction for chloride.

In the course of these experiments a further quantity of the oily hydrochloride soluble in ether was obtained, but there is some doubt as to the definite character of this compound, and a further study renders it very doubtful whether it constitutes a product intermediate between the hydrocarbon and the crystalline hexahydrochloride.

Decomposition of Spinacene Hexahydrochloride by Heat.

I have previously directed attention to the fact that when this compound is heated to a temperature above its melting-point, hydrogen chloride is liberated. 2·14 grms. of the hydrochloride were introduced into a weighed test-tube, which was connected with a vacuum pump. The tube was then immersed in an oil-bath and heated for four hours to 150°. Hydrogen chloride was freely evolved, particularly at the commencement of the experiment, and at the end of the above time it was found that 0·32 grm. of hydrogen chloride had been lost. The heating was then continued, but as the evolution of gas became very slow the temperature of the bath was raised to 190°, at which temperature it was maintained for seven hours. At the end of this time a further 0·36 grm. of hydrogen chloride had been given off, making a total loss of 0·68 grm., the total amount present in the hydrochloride taken being 0·76 grm. At this point the evolution of hydrogen chloride had become so slow that the experiment was stopped.

The oil remaining in the tube was fairly mobile and of a pale red colour. The iodine value of this oil was 255·5, and it contained Cl = 5·2 per cent. A 10 per cent solution in benzene was found to be optically inactive.

From this experiment it would appear that the hydrocarbon left after expelling the hydrogen chloride by heat differs from the original spinacene in being less unsaturated, due probably to the occurrence of some intramolecular change, such as that involved in the conversion of pinene into camphene. The molecular weight of this oil determined by the depression of the freezing-point in benzene solution was 479, showing that, in addition to the above intramolecular change, there had been some polymerisation.

Action of Hydrogen Bromide. Spinacene Hexahydrobromide.

Dry hydrogen bromide was passed into a well cooled solution of spinacene in several times its volume of dry ether. Shortly after the liquid had become saturated a white substance formed which appeared to consist of a crystalline substance and an oil. A further quantity of dry ether was added, and the precipitate was separated, washed with ether, and dried. This substance was purified by dissolving it in benzene, adding alcohol until the separation of the compound just commenced, and finally by recrystallisation from benzene alone. After three recrystallisations the product appeared to be pure, and gave on analysis the following results:—

0·2061 gave 0·2640 AgBr; Br = 54·51.
$C_{29}H_{48}$,6HBr requires Br = 54·42 per cent.

As in the case of the hydrochloride it will be seen that this percentage accords much better with the formula $C_{29}H_{48}$ than with $C_{30}H_{50}$, the theoretical percentage of bromine in the latter case being 53·57.

The hexahydrobromide is a brilliant white crystalline compound closely resembling the hydrochloride in appearance as well as in respect of its solubility in the commoner solvents. As in the case of the hexahydrochloride the yield is not very large, oily compounds being formed at the same time. Thus in one experiment in which a solution of 5 grms. of spinacene in 10 cc. of ether was saturated with hydrogen bromide and allowed to remain for twenty-four hours, the yield of the hydrobromide did not exceed 6·5 grms. When heated the crystals soften at about 126° and melt to a clear liquid at about 132°. When heated to a still higher temperature decomposition occurs, hydrogen bromide being freely evolved.

I have devoted a good deal of care to the purification of the hydrochloride and hydrobromide of spinacene, since these compounds are definite and well crystalline, and consequently afford the best indication as to the correct molecular formula of the hydrocarbon. It will be seen that all the results given above agree well with the formula $C_{29}H_{48}$, and although the other derivatives described in my previous communication are less well defined than the hydrogen haloids and not very easily purified, attention may be directed to the fact that, with one exception, the analytical results in all cases agree better with the formula $C_{29}H_{48}$ than with $C_{30}H_{50}$. This will be more clearly seen by reference to the following numbers:—

	Found.	$C_{29}H_{48}$.	$C_{30}H_{50}$.
Spinacene trinitrosochloride—			
Cl = ...	18·48	18·00	17·50
N = ...	7·36	7·10	6 92
Spinacene trinitrolpiperidide—			
N = ...	11·52	11·38	11·20
Spinacene trinitrolbenzylamide—			
N = ...	10·58	10·45	10·27
Spinacene hexanitrosochloride—			
N = ...	10 62	10·65	10·46
Cl = ...	27 42	27·00	26·52
Spinacene nitrosate—			
N = ...	12·80	12·50	12 30

The single exception referred to above is the dodecabromide, which contains Br = 69·7 as compared with 70 79 per cent required for the lower molecular formula and 70·07 per cent for the higher. I have already indicated, however, that the action of bromine on spinacene is very complicated, both addition and substitution derivatives being simultaneously formed. The bromine compound is, moreover, either insoluble or only very sparingly soluble in the great majority of the ordinary organic solvents, and could only be purified by the addition of alcohol to its solution in tetrachloroethane. It is quite possible, therefore, that this compound has not as yet been obtained in a state of purity.

Action of Nitric Acid on Spinacene.

Nitric acid (D 1·42°) mixed with an equal volume of water was added to spinacene and the mixture warmed. A very vigorous reaction occurred with the evolution of oxides of nitrogen. After the reaction had subsided water was added, and the solid substance which was formed was collected, washed, and dried. It was purified by dissolving it in aqueous sodium hydroxide and by completely saturating the solution with carbon dioxide. The precipitate which formed was separated by filtration, and the clear filtrate, on acidification with dilute sulphuric acid, gave a further precipitate. The latter substance was almost insoluble in ether or petroleum, but moderately soluble in alcohol. It dissolved readily in glacial acetic acid, from which solvent it was obtained by the gradual addition of water as a pale yellow precipitate.

It is clear that in the above experiment at least two products are formed, and doubtless others could be obtained by modifying the conditions of nitration.

Decomposition of Spinacene by Heat in the presence of Sodium.

At the commencement of this paper I referred to the fact that a considerable quantity (about 500 cc.) of spinacene had been distilled over sodium at temperatures corresponding with a pressure of about 45 mm., and that evidence was obtained that under these conditions some decomposition had occurred. The oil which distilled over between 280° and 295°, and measured about 400 cc., was submitted to fractional distillation (without sodium) under a pressure of about 40 mm. The following four fractions were finally obtained:—

1. 84—88° (about 60 cc.).
2. 155—175° (about 60 cc.).
3. 220—275° (about 80 cc).
4. 295—298° (about 150 cc.).

An almost colourless viscous substance remained in the flask.

The first of the above fractions, which consisted of a fragrant mobile liquid, was purified by steam distillation, followed by fractional distillation. The greater portion (about 50 cc.) boiled constantly at 69°/20 mm:—

0·1097 gave 0·3470 CO_2 and 0·1268 H_2O; C=86·26; H=13·02.
0·1121 gave 0·3555 CO_2 and 0·1301 H_2O; C=86·48; H=12·89.

From the above it was clear that this liquid consisted of a hydrocarbon and contained about 0·6 per cent of oxygen. It was therefore redistilled several times over sodium, and the portion boiling at 51—54°/10 mm. again submitted to analysis:—

0·1291 gave 0·4120 CO_2 and 0·150 H_2O; C=87·02; H=12·90.
$C_{10}H_{18}$ requires C=87·0; H=13·0 per cent.

This hydrocarbon boils under the ordinary pressure at 170—175°, a little polymerisation apparently occurring during the process. It is optically inactive. The following molecular weight determination was made by the cryoscopic method:—

0·4021 in 16·36 benzene gave $\Delta t = -0·909°$; M.W.=135.
$C_{10}H_{18}$ requires M.W.=138.

Its specific gravity at 15°/15° = 0·8149 and at 20°/20° = 0·8125.

Its index of refraction at 15° = 1·4588 and at 20° = 1·4565.

Its specific refraction calculated by the $\frac{n^2-1}{(n^2+2)d}$ formula is 0·3353, and the molecular refraction is 46·3.

Taking Conrady's average numbers for the atomic specific refractions (D line), $C_{10}H_{18}$ with one ethenoid linking requires 45·8.

The following estimations were made of the amount of bromine capable of uniting with the hydrocarbon. The bromine was dissolved in carbon tetrachloride and added to a carbon tetrachloride solution of the hydrocarbon under water, the liquid being cooled by means of ice. By working in this way a correction could be made for the small amount of hydrogen bromide formed as the result of simultaneous substitution. The following are the results of two experiments:—

	A.	B.
Substance taken (grm.)	0·1878	0·1348
Bromine uniting with hydrocarbon (grm.)	0·2264	0·1646

Both these numbers are in close agreement with the addition of two atoms of bromine to one molecule of the hydrocarbon.

All these results point to this substance being a *cyclo*-dihydroterpene, and its properties appear to suggest that it may prove to be identical with *cyclo*dihydromyrcene or with *cyclo*linaloolene. It may be of interest to give for purposes of comparison the physical properties of *cyclo*-dihydromyrcene (*Ber.*, 1901, xxxiv., 3128) and of *cyclo*-linaloolene (*Ber.*, 1894, xxvii., 2521):—

	Hydrocarbon from spinacene	*cyclo*Di-hydro-myrcene.	*cyclo*Lina-loolene.
Molecular formula	$C_{10}H_{18}$	$C_{10}H_{18}$	$C_{10}H_{18}$
Boiling-point	170—175°	169—172°	165—167°
Specific gravity	0·815	0·828	0·811
Refractive index	1·459	1·462	1·460
Number of atoms of bromine added	Two	Two	Two

Had time permitted specimens of *cyclo*dihydromyrcene and of *cyclo*linaloolene would have been prepared for the purpose of making a fuller comparison. This I hope will be done at some future time. In the above work steps were taken to make it quite clear that this terpenic hydrocarbon was not formed by the action of sodium on the small amount of oxygenated constituent occurring in the spinacene used. To this end the spinacene, after having been distilled over a considerable excess of sodium under 10 mm. pressure, was then redistilled over a further quantity of sodium under 40 mm. pressure. From the distillate the terpenic hydrocarbon described above was separated by steam distillation. The recovered and unchanged spinacene was then for a third time distilled over sodium under 40 mm. pressure, with the result that a further quantity of the terpenic hydrocarbon was obtained. There can therefore be no reasonable doubt that this *cyclo*-dihydroterpene does, in fact, result from the breaking up of the spinacene molecule. The view which I ventured to put forward in my first communication, that spinacene would prove to be related in some way to the terpenes, is therefore correct. The presence in large quantities in fish-liver oil of a complex hydrocarbon closely related to the terpenes is, I think, of very considerable interest both from the chemical and from the physiological points of view. In this connexion it may be recalled that there is very strong evidence that cholesterol, a substance having nearly the same number of carbon atoms in its molecule as spinacene and occurring also in fish-liver oils, is a complex terpene compound.

The second fraction obtained from the decomposition of spinacene was also a fragrant tolerably mobile liquid boiling at 109—115°/10 mm., having an average molecular weight of about 190 and a specific gravity at 15°/15°=0·868 and at 20°/20°=0·865. This, as well as the viscous products left in the distillation flask, which doubtless consist of polymerisation products formed during the process, will, it is hoped, be subjected later on to a further study. Except perhaps in one direction in which results of industrial importance may be anticipated, the further examination of spinacene and its derivatives will have to remain in abeyance until more normal conditions again prevail.

I desire to express my thanks to Miss D. J. Minter and Mr. C. W. McHugo for valuable assistance in connection with this work.

Herb Growing.—One of the happier results of the war has been the revival of herb growing in this country, thanks very largely to the public-spirited zeal of lady gardeners and others who are aiming to supply the needs of a market which had hitherto been far too dependent upon Germany. Much of our oldest garden lore has its origin in the early Herbals, which instructed our fore-fathers in all the useful points of husbandry, besides the cultivation of herbs for medicine; but long before the war we had allowed the industry itself, for all serious medical purposes, to pass into German hands. In order to foster the present movement for the revival of this pleasant craft, a handbook on this subject, full of varied information, has been written by Dr. David Ellis, Professor of Botany in the Royal Technical College of the University of Glasgow, and will shortly be published by Messrs. Blackie, entitled "Medicinal Herbs and Poisonous Plants."

THE VERTICAL RETORT OF THE SHALE-OIL INDUSTRY.*

By G. T. M'KILLOP.

The shale-oil industry owes its existence to Dr. James Young, who in 1847 had his attention directed to a small stream of oil flowing from the top of a coal-working at Alfreton, Derbyshire. The supply became very soon exhausted, and Dr. Young then set out to imitate the process by which he thought the oil had been produced, by the action of a gentle heat on coal, and in 1850 he brought out his famous patent for "obtaining paraffin, oil, or an oil containing paraffin from bituminous coals by slow distillation." During the progress of his experiments a highly bituminous mineral called Boghead coal or Torbanehill mineral was found near Bathgate. It contained from 60 to 70 per cent of volatile matter, and on slow distillation gave from 120 to 130 gallons of crude oil per ton. This mineral was worked out by 1862. The retorts first erected at Bathgate were the ordinary horizontal gas-retorts, coal-fired, and I do not think any attempt was made to utilise the permanent gas as fuel. The condensed water containing ammonia, sulphides, &c., was allowed to pollute the neighbouring streams. Although oil-works and gas-works have retorts in common, their ultimate objects diverge. The oil-works try to make as much oil as possible at the lowest possible temperature; gas-works use a high temperature to get a large yield of gas. Even at that early age in oil-retort evolution Young was not satisfied with the quality of the oil, and about two years afterwards he erected three cylindrical cast iron retorts vertically in a fire chamber common to the three. The tops were surrounded by hoppers, and the bottoms were sealed by dipping into troughs of water. The retorts were some 18 inches diameter and about 11 feet high. Owing to the tendency of the Boghead mineral to swell and stick in the retort, Young next devised a tapered cylindrical retort, set in brickwork, with the larger end down and sealed in water. Each retort was fitted with an internal helical screw, the shaft projecting upwards, and driven from a main shaft by a gear. The helical screw was kept in slow motion, and carried the contents of the retort slowly downwards and prevented sticking. This method was quite successful, and was continued for eight years. Then a new shape of retort was devised with an elliptical cross section and much larger at the bottom than the top. The retort gave the fire a greater surface to play on, and less depth of material for the heat to penetrate.

The advantages of the vertical retort over the horizontal for oil-producing purposes were early realised. A larger yield of oil of better quality was obtained due to the better and easier regulation of the temperature.

In 1861 it was found that a current of steam passed up through the shale increased and improved the yield of oil, and the yield of ammonia also was doubled. Steam in the horizontal retort was not so effective, as it passed over the top of the shale. The progress made in retorting shale may be summarised thus:—1. Adoption of a vertical retort. 2. Construction of a retort with an elliptical cross-section. 3. Introduction of steam at the base of the retort.

The next step forward was to try to utilise the carbon left in the spent shale (about 12 per cent) to give gas. The former retorts were worked at the lowest possible temperature to get good hydrocarbon oil, and did not give enough permanent or uncondensable gas to fire themselves. They had to be assisted by coal fires. The Henderson retort of 1873 was the first of this series, and was very successful. These retorts were of cast-iron, elliptical in cross section, and were placed in a vertical position in an oven that was common to four. This retort effected a saving of 50 per cent in coal as fuel over the other retorts, mainly due to the gas, which has a high calorific value, assisted by the combustion of the residual carbon in the furnace. This was a good oil-retort, but wasteful of ammonia, as the nitrogen in the badly exhausted shale did not form ammonia but was lost in the spent flue gas. From this type of retort with a good shale the yield was 27 gallons of oil per ton and 14 lbs. of sulphate of ammonia.

The next advance was the retort of Messrs. George T. Beilby and William Young in 1881. This quickly superseded all the other forms, as it gave a good yield and quality of oil and utilised the carbon and nitrogen in the oil-exhausted shale to give gas and ammonia. The modern retorts are modifications of this one, which brought up the yield of ammonia from 14 lbs. in the Henderson retort to 40 lbs.

We now come to our present-day retorts and method of working. The shale is brought up from the mines in hutches by an endless rope, tipped into a shoot, and crushed between heavy toothed rollers into lumps of 5 lbs. and less. From the shale-breaker it is delivered into hutches holding about 18 cwt., and conveyed by endless rope to the top of the retort-bench, and there emptied into the charging tanks or hoppers of the retorts.

The present Henderson retort is vertical, the total height from the ground to the top of the bench being about 63 feet. The iron part of the retort is elliptical in shape and tapered, and is surmounted by a hopper carrying a twenty-four hours' supply of shale. The iron part is 2 ft. $9\frac{1}{2}$ in. by 1 ft. $2\frac{3}{8}$ in. at the top, and 3 ft. by 1 ft. 5 in. at the bottom, and is 14 ft. long. The bottom part of the retort is of fire-brick, rectangular in shape and 20 ft. long. The taper is continued, and at the base of the brick retort the dimensions are 4 ft. 8 in. by 1 ft. 10 in.. Here are two toothed rollers which support the column of shale and regulate the speed at which it is allowed to come down through the retort. Beneath the rollers is an iron receptacle to receive the spent shale. This is emptied four times in the twenty-four hours, and the exhausted shale is sent to add to the large heaps which are seen adjacent to all shale works. In a bench there are two rows of retorts—twenty or more in each row. The bench is built up 6 ft. clear of the ground, to allow the hutches to be run under to discharge the spent shale.

The superiority of the present Henderson retort over its predecessors is that no coal gas or producer gas is required to aid the retorting of the shale. From the shale itself, without deteriorating the quality of the oil or sacrificing any of the condensable products, sufficient gas of good calorific value is obtained to maintain the necessary temperature of the retort, and this with shales much inferior to those which used to be put through the old retorts. The fuel gas is led along each side of the bench of retorts at a pressure of 6 inches, and the gas is led into the bottom of the brick retort by 2-inch pipes—three pipes for every two retorts, each pipe controlled by a valve. The centre pipe feeds the middle flue, which runs from front to back, then up and from back to front, up again, and so on till it reaches the oven of the iron retorts. The oven has four retorts, and the spent gases are drawn off by two vertical flues in the sides of the oven. These flues are controlled by dampers, and the burnt gases are allowed to escape into the atmosphere from short iron chimneys carried up to clear the charging hoppers. When working, the base of the retort is at the highest temperature, that of the flues being 1100° C. at the two bottom rows of ports. The heat decreases higher up the retort, being about 800° C. at the junction of the iron and brick retorts and 600° at the middle of the oven in which the iron retorts stand. These are flue temperatures, and necessarily higher than the actual temperature inside the retort.

The shales move slowly down from the charging-hopper into the iron retort, where it meets the hot products of distillation coming up, and as it moves on it is subjected to slowly increasing heat. By the time it is through the iron retort the "kerogen," or oil-forming material, has been distilled off at the lowest possible temperature, and

* A Paper read before the Scottish Junior Gas Association, Western District. From *Chemical Engineering*, May, 1918.

in the presence of steam, which protects the hydrocarbons. The partially exhausted shale containing carbon and nitrogen, moves slowly downwards into the fire-brick retort, and as it descends is subjected to a rapidly increasing temperature and the action of a current of steam. The carbon and steam react, giving hydrogen and carbonic acid, and some carbonic oxide when the temperature is high enough, and the ammoniacal nitrogen is involved from the shale in the form of ammonia. The presence of a liberal supply of steam prevents the decomposition of the ammonia during its passage through the hot area. After passing the rollers the exhausted shale drops into the bottom hopper and is withdrawn at regular intervals.

The condensed ammonia water is about 100 gallons per ton of shale, and the quantity of sulphate of ammonia from 40 lbs. to 60 lbs., according to the particular seam. A good oil shale will yield 25 gallons of oil per ton of 0·868 sp. gr., and give 8000 cubic feet of permanent gas, containing 56·8 per cent of combustible matter. The volatile matter in good shale (Broxburn seam) is 25·5 per cent; the residue, 74·5 per cent. The ultimate percentage composition of volatile matter is:—Carbon, 19·12; hydrogen, 2·94; nitrogen, 0·54. From every 100 tons of shale put through there are 75 tons to be drawn and put on the heaps, and as we put through upwards of 2000 tons per day it can be understood that the heaps in the shale districts are rapidly becoming mountains. The life of these large retorts is proportional to the usage they get. If they are overdriven by too much shale being put through, then the flue temperatures have to be raised and the retorts stick and give trouble. We find our retorts are good for some eight or nine years without any great amount of repairs. The retorting is continuous.

The products of destructive distillation at this stage are crude oil, condensed water containing ammonia, and gas. There is no difficulty in separating one from another. The oil is light, floats easily on the water, and is not viscous. The scrubbed gas goes to fire the retorts; the condensed ammonia water and water from the scrubbing towers is pumped into the Henderson ammonia stills, where the ammonia is driven off and trapped in a saturator with sulphuric acid. The sulphate of ammonia made is almost white, with 25 per cent of ammonia when dry. The crude oil, of 0·870 to 0·875 sp. gr., which is dark brown in colour with a green fluorescence, and which solidifies at about 80° F., is pumped across to the refinery and dealt with there.

Distillation gives from the crude oil:—(1) Crude motor spirit and naphthas; (2) light oil, once run; (3) heavy oil and paraffin, once run; (4) heavy oil and paraffin from the pot stills with coke as a residue and a quantity of permanent gas. The coke is valuable, as it contains only about 1 per cent of ash. The gas is collected, and a quantity goes to the gasholders to light the village, *the surplus being returned to heat the stills. The fractions* are refined with oil of vitriol, which removes a quantity of heavy tar, treated with weak soda to remove traces of acid, and separately re-distilled. This treatment and distillation process is repeated until the products are at marketable standard.

The products obtained by the fractional distillation and refining of crude oil are (in addition to gas and coke):—

	Per cent.
Motor spirit, 0·715 sp. gr.	3·5 (with next)
Naphthas, 0·730—0·745 sp. gr.	
Oil for internal combustion engines, 0·770—0·785 sp. gr.	30·3 (with next two)
Lamp oils, 0·795—0·805 sp. gr.	
Lighthouse oil, 0·810 sp. gr.	
Gas or fuel oils, 0·850—0·865 sp. gr.	10·4
Lubricating oils, 0·885—0·895 sp. gr.	28·8
Paraffin wax—	
Soft, melting-point 100—110° F.	4·0
Hard for candles, melting-point 120—125° F.	6·1
	73·1

The loss in refining is in tar and decomposition of hydrocarbons giving gas and coke. The proportion of products obtained varies within limits according to the temperatures employed in distilling and the quantity of steam used. The lighter oils are becoming increasingly utilised for internal combustion engines, as they are of high calorific value—about 19,000 B.Th.U. per pound; and if combustion is good the products are harmless. The gas or fuel oils, which used to be largely taken by gas-works and railways to enrich poor gas or to make oil gas, which is very compressible, are now being very much employed by high-speed vessels of the Navy. It is the ideal fuel for rapid steam-raising. It is light in weight, and not easily frozen, even by extreme cold. One ton is almost as good as two tons of coal, and with a proper burner it is smokeless.

Formerly the gas went to waste, and we had a small gas-works. Some years ago it was considered worth while to connect up the gas outlets of the coking-stills, and we found we had an ample supply of a good gas, practically free from sulphur, containing no carbon monoxide, and of high illuminating value. The coal retorts were stopped, and the gas, mixed with air to make it suitable for use with mantles, was sent to the gas-holder. It does very well, and the purifiers can run for months without attention. The composition of the gas is rather peculiar, as it is a mixture of permanent gas, very volatile hydrocarbons, and air. We found the proper admixture of air quite easy to regulate by having incandescent burners, upright and inverted on the inlet and outlet supply in the pumping house, and the man in charge kept these giving a good and clear light. When the gas gets poor or too rich it is passed to the furnaces. With a little practice the man keeps his mixture right within 3 per cent.

GREAT BRITAIN'S INTEREST IN THE METRIC SYSTEM OF WEIGHTS AND MEASURES.

By HARRY ALLCOCK, M.I.E.E., A.M.I.Mech.E.

1. WHEN the war is over it must be paid for. The burden of post-war taxation can only be lightened by increased production, and by the sale of these excess products to overseas consumers.

2. Provided always that the menace of a conflict between Capital and Labour is removed without reverting to "restriction to output," and that adequate supplies of raw materials and cheap power are assured, we shall find ourselves at the end of the war with enormously increased resources for cheap production as compared with our pre-war position. The capacity of our industries to absorb the labour of our demobilised fighting forces will thus depend mainly upon our ability to increase the demand for our goods.

3. Unfortunately, our sales organisations have necessarily been neglected during the war period, and in addition to the fact that other countries have not failed to profit by our temporary inability to execute overseas orders, we must bear in mind that post-war economic pressure will intensify the international struggle for commercial supremacy.

4. We shall accordingly find ourselves confronted by unusually keen competition abroad at a time when the national interest demands an enormous expansion of our overseas trade. It will thus be just as necessary for us to organise our export trade as it was for us to organise, for instance, the manufacture of shells and other war munitions.

5. This necessary organisation and development of our export trade will demand the elimination of all hampering influences. In this connection it will then be remembered that for years past our overseas representatives—both Government and private—have urged the importance of

our more extensive use of the international metric system of weights and measures which so many of our present and potential overseas customers already employ. (The use of the metric system is obligatory in 34 countries, representing a population of over 437 millions, and optional in a further 11 countries having a population of over 727 million people).

6. Whether we like it or not, we already find ourselves compelled to use the metric system for a portion of our trade and to an ever increasing extent. The retention of our own British system thus compels us to handicap ourselves by working in two systems where one would suffice. For the reassurance of those who, having no intimate knowledge of the metric system, feel some alarm at the suggested abandonment of the British system in its favour, the following statement by the Right Hon. A. J. Balfour, M.P., may be quoted. Replying to a deputation in 1895 he said:—

> "Upon the merits of the case, I think there can be no doubt whatever that the judgment of the whole civilised world, not excluding countries which still adhere to the antiquated systems under which we suffer, has long decided that the metric system is the only rational system."

7. Germany employs one system—the metric system—throughout her laboratories, workshops, home trade, and foreign trade. Britain employs the metric system in her laboratories, the British system and the metric system in her workshops, the British system for our home trade, and the metric system for part of her export trade. (Our Colonies have already signified their desire to adopt the metric system simultaneously with the Mother Country).

8. When we realise that our national existence depends upon our ability to sell British manufactured goods to all nations, *i.e.*, to develop a world-wide trade, it will be apparent that Great Britain, more than any other country, would benefit from the establishment of a universal system of weights and measures. It will be obvious that our adoption of the metric system would establish it as the universal language of quantity, but, on the other hand, it is equally clear that the British system could never become the universal system, because of its inherent defects. In the early seventies Germany adopted what was then known as the French metric system, notwithstanding the anti-French sentiments then existing on account of the Franco-Prussian war. Since that date the use of the system has been extended to 24 additional countries, and it is now truly described as the international metric system. These facts should be borne in mind by those who may be inclined to consider that our adoption of the metric system would benefit Germany more than ourselves.

9. At the end of the war British manufacturers will not merely revert to their pre-war standard products—new designs and new methods will be the order of the day, and a unique opportunity is thus presented for the reorganisation of British firms on the metric basis. If all sales were then compulsorily made in terms of the metric system it would follow that all new designs, patterns, &c., would be prepared on the metric basis, but the old patterns, &c., could be continued in use for manufacturing purposes until they became worn out or obsolete. In selling the products of these old British-dimensioned patterns, &c., all dimensions in tenders, invoices, &c., would be given in metric equivalents, just as we do to day in our export departments. With the passage of time such conversions would naturally decrease in volume, and finally disappear, whereas, under existing circumstances, they must increase continuously.

10. In some cases where the coincident use of the British and metric systems during a transition period could be shown to be especially inconvenient, it would not be unreasonable for the Government to bear the cost of the change by, for instance, allowing the firms in question to retain out of the amount they would otherwise pay in excess war profits a sufficient sum to enable them to replace their present stocks of British-dimensioned patterns, &c., by new metric patterns, &c. Any costs so borne by the nation as a whole would be speedily reimbursed to the taxpayer through the medium of the reduced taxation rendered possible by the consequent expansion of our export trade and its attendant benefits.

The value of the collateral advantages accruing to the entire community from our adoption of the metric system (*e.g.*, the economics of time and labour in education, in calculations involving quantities and dimensions, in communications between the scientists, the producers, and the consumers of the world) cannot be expressed in money, but it would be admittedly very great.

It should also be remembered that the longer our adoption of this inevitable reform is deferred the greater will be the magnitude and extent of the incidental difficulties to be overcome.

COAL SAVING BY THE SCIENTIFIC CONTROL OF STEAM BOILER PLANTS.

An important paper on the above subject appeared recently in *Engineering* (July 12 and 19, 1918) detailing some exhaustive tests of the efficiency of a number of typical steam boiler plants in England, Ireland, Scotland, and Wales.

The results show tha the average nett working efficiency of steam boiler plants is 60 per cent, while by adopting scientific methods of working 75 per cent efficiency is quite possible.

The author of the article, Mr. David Brownlie, B.Sc., F.C.S., gives a number of very interesting figures, and in conclusion states:—

No attempt is made to purchase fuel on scientific lines, on the actual heating value of the fuel supplied and its suitability for the particular conditions of the given boiler plant. No check is kept on the cost of production of a unit of steam and on the general performance of the plant. Thousands of factories are short of steam in spite of the fact that a very moderate amount of reorganisation of the boiler plant would give all the extra steam required from the same number of boilers, and the reorganisation would be paid for in a few months by increased factory production. Thousands of boiler plants are being worked under shocking conditions as regards attention to repairs and up-keep conditions which would not be tolerated for a moment in connection with engines and general machinery.

The reason of this deplorable state of affairs is, first, because the question of the economical generation of steam is essentially the business of a specialist, comprising a combination of technical chemistry and engineering quite outside ordinary practice. It seems very probable that the conditions of steam generation in this respect are much the same all over the world. The author has examined a number of steam boiler plants in France, and the general working conditions appear to be very similar. In the United States the average working efficiency does not seem to be more than about 60 per cent, on a coal bill at the present time of certainly over 300,000,000 tons per annum.

Secondly, in Great Britain at any rate, the trouble is due to conservatism, to a general disinclination to apply modern methods of applied science and organisation, a characteristic that applies to many other national questions besides that of coal economy.

What is required at once is that a quick survey should be made of all the boiler plants of the country by the few real experts on the question we possess.

This work cannot be done by amateurs or by people who are unused to technical conditions and organisation. When such a rapid survey has been made an immediate

reorganisation of the largest and most wasteful of the boiler plants of the country should be carried out, together also with the utilisation of the large stocks of refuse coal at many collieries for boiler plants working under easy conditions as regards steam output. There is not the slightest doubt that at least 500,000 tons of coal per annum could be saved in this way, commencing in six months time, and the necessary labour and material for the reorganisation would be very small in comparison to the national saving obtained. If priority certificates for plant and machinery were granted only to work of real national importance the labour and material required for reorganising existing steam boiler plants on the above lines would be far less than that now taken up by work of no importance whatever. Such a scheme would have the additional advantage of releasing a large number of steam boilers, probably 300 to 400 in six months, and economising steel now being used to make new boilers, as the reorganisation would include the shutting down of many boilers and working the remaining boilers at the proper steam output. The cost of the reorganisation could, if necessary, be borne by the Government, and would, in fact, be a most profitable investment.

The larger question of a great national scheme of economical utilisation of our coal resources requires the most careful and thorough investigation with a vast amount of experimental and research work, and we have urgent need of every experienced man in the country to unite and concentrate upon it.

Whatever national method or methods of reorganisation is finally adopted for power production it has to be remembered that a very large amount of steam will always be required in industry for heating, boiling, and general technical processes quite apart from power production, and this amount will probably correspond to between 15,000,000 tons and 30,000,000 tons of coal per annum. The question of the economical generation of steam will therefore always be a very important part of the greater national scheme of coal economy, even if all the power in the country is generated by gas-engines and the by-products of the distillation of coal. In such an event the fuel for steam raising will probably be chiefly coke and coke breeze. If, however, it is decided that a large part of our power is to be produced by steam plant, then the question of economical steam generation will be of still greater importance.

In any case the immediate reorganisation of the largest and most inefficient plants could be undertaken chiefly in connection with those plants which will always require to produce a large amount of steam for purposes other than power production, so that the reorganisation would fit in with the future and larger scheme of national coal economy to be applied to the whole country.

German Industry and the War.—The *Société de Chimie Industrielle* has recently issued a special number dealing with German industry and the probable effects of the war upon it. The industrial condition of Germany before 1914 is described, and the excellent means now being adopted to better her position are pointed out, high tribute being paid to her spirit of investigation and organisation. Finally, Germany's post-war aims are reviewed, and the lessons that France and all the Allies have to learn are put forward very strikingly and clearly. It is shown that Germany is concentrating all her attention upon measures for regaining her position in the world markets, and the need for reform in the training of science students in France is emphasised. Laboratory work and chemistry generally need more encouragement, and, as in England, science and industry must be brought into closer co-operation. It is an encouraging sign that the *Société de Chimie Industrielle* is rapidly increasing in membership and resources, and its efforts deserve and will no doubt attain to success in the highest degree.

ROYAL SOCIETY.

MEMORANDUM OF COMMITTEE ON INTERNATIONAL SCIENTIFIC ORGANISATIONS.

INTERNATIONAL scientific organisations and conventions may be divided into four groups according to their objects and methods of procedure. Some are intended to establish uniformity in the standards of measurements, others to advance science by co-operation, and others, again, merely to encourage personal interchange of opinion. Those that aim directly at organising scientific progress may further be divided into two parts, according as the co-operation is essential to co-ordinate observations taken in different places or aims only at economy of labour.

We may form therefore a first group consisting of those important agreements which fix the standards of measurements, and are essential not only in purely scientific investigations but in the development of many industries. The foremost position in this group is held by the International Metric Commission with the "Bureau International des Poids et Mesures," which has its headquarters at Sèvres, and mainly deals with the fundamental standards of length and mass.

Other units which, though intimately connected with the metric system, require special consideration are generally entrusted to special international bodies. Thus, the electrical standards were fixed at international conferences called at different times for the purpose. At the last of such meetings, held in London in 1908, it was resolved that a recommendation should be sent to the Governments interested advising the establishment of a permanent international commission. Though no official action seems to have been taken, a scientific committee appointed by the conference under the Presidency of Lord Rayleigh has done much valuable work. In the meantime the need for agreement in matters affecting the electrical industries has led to the promotion of an Electro-Technical Commission for the purpose of "the standardisation of the nomenclature and ratings of electrical apparatus and machinery."

Comparatively few of the organisations falling within this group depend entirely on Government recognition or support. Several, like the "Solar Union," to whom we owe the fixing of standards of wave-lengths in different parts of the spectrum, and the Committee on "Atomic Weights" are formed by the voluntary co-operation of scientific societies in different countries.

The second group contains associations definitely formed for the investigation of scientific problems in which co-ordination of observation is essential. Such were the "Geodetic Association," and the "Seismological Association," which depended on conventions entered into by the Governments of the countries forming the Associations and the International Meteorological Committee.

A third group, which hitherto has not been large in numbers, but presents some special features, embodies the efforts to organise undertakings that might be carried out in one locality, but is more economically dealt with by a division of work. The most prominent example of this type is the arrangement made between eighteen observatories to form a photographic chart of the heavens. Great Britain alone with its colonies could have undertaken the task, and six out of the eighteen observatories concerned are actually in its dominions. But it is clear that the time necessary to complete it is shortened by increasing the number of stations at which photographs are obtained and measured.

The organisation dealing with the "International Catalogue of Scientific Literature" may also be included in this group.

In the fourth group we place the large number of congresses called together by workers in some one department of science, and mainly intended to foster friendly personal relationships between those who pursue similar aims in different countries. There have been regular international

meetings of mathematicians, geologists, botanists, &c.; but these do not—at any rate in the great majority of cases—depend on formal agreements or conventions, each meeting selecting the place for the next conference, which generally is held after an interval of three years.

We have, finally, in a group by itself, the International Association of Academies, which aims at co-ordinating the activities of international undertakings, and organises work for which special permanent bodies do not exist and are not required. This Association has a scientific and literary division.

In Appendix A, a list (doubtless not complete) is given of the various international associations and congresses according to the groups into which they fall. Appendix B gives in the case of a few typical examples their constitution or method of working.

In discussing the future of these organisations it will, in the first instance, be found convenient to consider those which depend on Government support, for it is mainly with regard to them that a conference between the academies of the Allied Nations is important. They may be called upon in the near future to advise their Governments, and it is therefore highly desirable that a common policy should be agreed upon. Such a policy could then also be taken as a guide in the case of those conventions which depend upon agreement between the scientific societies themselves. The scientific congresses of the fourth group may, for the present, be left out of account, though advice from the academies may also here be of ervice.

The more formal organisations which mainly make up the three first groups, though similar, present so many differences in important respects that it is difficult to deal with them as a whole, and almost each subject needs special consideration. It becomes important therefore to establish, if possible, some guiding principle which may be applied to the majority.

It must be recognised that international meetings in which, as hitherto, social intercourse forms an important part will not for some time be possible. In some cases, such as the interchange of meteorological observations, of time signals, or the communication of exceptional astronomical occurrences, formal correspondence, re-established at the same time as diplomatic relations, might suffice. In the great majority of cases where this is not possible the question arises, whether the organisations could not be suspended altogether for a number of years without serious detriment to science.

One pertinent fact of some significance remains to be noted in connexion with the activities of the old Geodetic Association which had its headquarters at Potsdam. During recent years the work was almost entirely confined to observations on variations of latitude. These were carried on at six observatories, all situated very near the same circle of latitude (39° 8′), and belonging to countries at present, or till recently, at war with Germany—three are in the United States, one in Italy, one in Russia, one in Japan.

The objection raised to the foundation of two separate groups of international organisations, on the ground that it would perpetuate a state of war after peace is concluded, loses much of its force if alternative solutions be considered. It need not be assumed that there will be any active enmity between the two groups. Interchange of information may be carried out by correspondence, and their relations will depend on the nature of the peace that is concluded and the future history of Europe. A forced community of effort through the intermediary of the neutral countries seems more likely to become detrimental to the success of the scientific work to be done than a frank avowal of the fact that the feelings aroused by the war must necessarily survive its conclusion.

A number of special cases present themselves where some one academy or body has taken such a leading part that propositions as to the future of the organisation concerned must be left mainly to that body. Such is, for instance, the "Commission Métrique Internationale," with its "Bureau International des Poids et Mesures" at Sèvres, near Paris; the Académie des Sciences will, no doubt, have specially considered how this body may have to be modified. The Royal Society has taken the initiative in the International Catalogue of Scientific Literature, and a Committee of the Joint Board of Scientific Societies is formulating suggestions which, it is hoped, may soon be ready for submission to the Allied Academies.

The Chemical Society of London will have to be consulted on the International Committee of Atomic Weights, and in other cases where the academies are not the bodies chiefly concerned further information and advise will have to be obtained.

The Council of the Royal Society, inviting the academies of the Allied Nations and of the United States to a conference for the purpose of deciding on a policy to be adopted with regard to International Organisations, submits the following questions as subjects for discussion at the conference:—

1. Is it desirable for the Allied nations to establish organisations for scientific co-operation among themselves?
2. If this be agreed upon, what should be the particular forms of organisation to be aimed at in Geodesy, Seismology, Meteorology, &c.?
3. Should particular academies be asked to submit proposals on those undertakings in which they have taken the leading part, such as—
   (a) The Académie des Sciences on the Commission Métrique and the Bureau International des Poids et Mesures;
   (b) The Royal Society on the International Catalogue of Scientific Literature.
4. What representations should be addressed to the Governments with regard to those orgrnisations which have hitherto received their support?

The conference at present is intended to deal only with scientific subjects, but similar questions no doubt also arise on the literary side.

Appendix A.—*List of some of the Principal Internationa Organisations.*

Group I.—*Agreements on Standards and Methods of Observation.*

1. Commission Métrique Internationale, and Bureau Internationale des Poids et Mesures.
2. International Committee of Electrical Units and Standards.
3. International Electro-Technical Committee.
4. International Association for Testing Materials.
5. International Committee on Atomic Weights.
6. Comité International pour la Publication annuelle de Tables de Constantes Physico-chimiques.
7. Commission on Illumination.
8. Conférences Internationales des Ephémérides Astronomiques.
9. International Meteorological Committee.
10. International Solar Union (see also Group II., 6).
11. International Telegraphic Union.
12. Agreements on Radio-telegraphy.
13. Bureau International de l'Heure.

Group II.—Associations formed for the purpose of investigating Scientific Problems in which co-operation between different nations is considered desirable.

1. Geodetic Association.
2. Association of Seismology.
3. Interchange of News concerning Astronomical Occurrences.
4. International Agricultural Institute.
5. International Council for the Exploration of the Sea.
6. Marey Institute.

7. Solar Union (see also Group I., 12).
8. Scientific Sub-Committees of the International Meteorological Committee.
9. International Committee for the Investigation of the Brain.

Group III.—Distribution of work bearing on the same problem for the purpose of Economising Time and Expenditure.

1. Astrographic Chart.
2. Carte Internationale du Monde au Millionième.
3. International Catalogue of Scientific Literature.

Group IV.—Periodic International Congresses serving mainly for friendly interchange of views.

1. Mathematics.
2. Chemical Societies.
3. Applied Chemistry.
4. Mining, Metallurgy, Engineering, and Economic Geology.
5. Radio-activity.
6. Botany.
7. Geology.
8. Zoology.
9. Entomology.
10. Ornithology.
11. Physiology.
12. Anatomy.
13. Anthropology.
14. Medicine.
15. Hygiene.
16. Cancer Research.
17. Medical Radiology.
18. Geography.

Group V.—International Association of Academies, serving to unify International work, organising it temporarily, preventing duplication of work.

A few years before the outbreak of the war an effort was made at Brussels to centralise all international undertakings, and an "Office Central des Institutions Internationales" was established. One of the publications of this office gives what purports to be a complete list of all international congresses, unions, and associations. Their total number is 279, but many of these are of a social or semi-political or trade character. Among those referring to science the following have not been mentioned in this Memorandum, either because no information was available, or because they do not fall within the range of discussion at the present moment:—

1. Association Internationale des Catholiques pour le Progrès de la Science.
2. Alliance Scientifique Universelle.
3. Office International de Documentation Aéronautique.
4. Commission Permanente du Répertoire Bibliographique International des Sciences Mathématiques.
5. Institut International de Statistique.
6. Comité Maritime International.
7. Comité Juridique International de l'Aviation.
8. Association Internationale d'Agronomie tropicale.
9. Commission Internationale pour l'Enseignement des Sciences Mathématiques.
10. Association Internationale pour Promouvoir l'Étude des Quaternions.
11. Association Internationale des Chimistes des Industries de Cuir.
12. Commission Internationale pour l'Étude de la Question de l'Unification des Méthodes d'Analyses des Denrées alimentaires.
13. Bureau International d'Ethnographie.
14. Association Internationale des Botanistes.
15. Comité Ornithologique International.
16. Association Internationale des Anatomistes.
17. Commission Internationale Permanente de Détermination des Phénomènes Psycho-biologiques et Socio-biologiques.
18. Office International d'Hygiène Publique.
19. International Sanitary Bureau.
20. Secrétariat International pour l'Unification des Pharmacopées.
21. Association Climatologique Internationale.
22. *Association Internationale* contre la Tuberculose.
23. Union Internationale des Stations Electriques.
24. Bureau International des Administrations Télégraphiques.
25. Association Internationale Permanente des Congrès de Navigation.
26. Association Scientifique Internationale d'Agronomie Coloniale.
27. Union Internationale des Stations de Recherches Forestières.
28. Union Internationale de Photographie.
29. Institut International de Photographie.
30. Association Internationale des Explorateurs Polaires.
31. Institut Polaire International.
32. Laboratoire International de Physiologie du Mont Rose.

APPENDIX B.

Group I.

1. The "*Bureau International des Poids et Mesures*" was established in 1873 at Sèvres as the outcome of an international commission constituted in 1869 for the construction of metric standards. The present convention was agreed upon in 1875. Great Britain joined the convention in 1884; the annual contribution now ranges between £200 and £300.

2. *The International Conference on Electrical Units and Standards*, which was held in London in 1908, recommended that the various Governments interested should establish a Permanent International Commission for Electrical Standards. The Conference requested Lord Rayleigh, as President, to nominate a Scientific Committee of fifteen members to formulate a plan of such Commission, and, in the meantime, to direct such work as would be necessary in connexion with the maintenance and inter-comparison of standards. This Committee has done much valuable work, but the intended Permanent Commission never came into being.

3. *The International Electrotechnical Commission* was formed for the purpose of carrying out a resolution of government delegates who met at the International Electrical Congress at St. Louis in 1904. This resolution was to the effect "That steps should be taken to secure the co-operation of the Technical Societies of the world by the appointment of a representative Commission to consider the question of the standardisation of the nomenclature and ratings of Electrical Apparatus and Machinery." The statutes of this Commission were finally adopted in their present form at a meeting held in London on October 22, 1908. They provided for the formation by the Sectional Societies of each country of Committees who shall represent that country on the International Commission. The central office is in London. Each Electrotechnical Committee provides funds for its own expenses, and contributes its share to the expenses of the Central Office. At the last meeting of the Commission Berlin (1913) 24 countries were represented.

4. *International Association for Testing Material.*—Six international congresses were held between 1884 and 1912 with a view to introducing greater uniformity in the methods of testing materials adopted in different countries. At the last two congresses (Copenhagen, 1909, and New York, 1912) England was represented. The resolutions of the congresses are not binding on anyone, and merely serve to express the opinion of the majority. Nevertheless, the work of this organisation has become of considerable importance. After the congress of 1912 a report of the British delegates advocating that the British Government

should continue officially to support the work of this Association was laid on the table of the House of Commons (*cf.* Sir James Wolfe-Barry, "Forrest" Lecture of the Institution of Civil Engineers, Appendix V., 1917.)

5. *Joint International Committee on Atomic Weights.*—This Committee grew out of an organisation formed by the leading chemical societies in Europe and America. It was placed on its present basis in 1901—1902, when the business of the Committee was entrusted to four men, being representatives of the chemical societies of America, England, France, and Germany respectively. The object of this Committee is to draw up annual reports on work connected with the determination of atomic weights, to consider the results, and to recommend any changes in the Tables of Atomic Weights which may seem desirable for promoting uniformity in teaching and in the literature of the subject. These annual reports were published each year until the outbreak of the war. The Council of the Chemical Society of London has appointed a small Committee to consider the future of this organisation.

6. *Annual Publication of Tables of Physical and Chemical Constants.*—This is an undertaking with its headquarters at Paris, managed by an International Committee. Special Committees have also been instituted in different countries (France, England, Germany, Holland, United States) to assist the work. The International Association of Academies has recognised the importance of the work, which, however, has suffered owing to insufficient financial assistance.

7. *International Commission of Illumination.*—The object of this organisation is "to study and advance by Congress and Publications, the knowledge and practice of the art of Illumination, and to secure international ageement on matters of general concern to the science and art of Illumination." It furnishes a good example of an association formed by scientific societies in different countries without Government assistance. Each country or self-supporting dominion desiring to take part in the work forms a national Committee through co-operation between technical societies interested in the subject of illumination. The British Committee is composed of representatives of the Illuminating Engineering Society of London, the Institution of Electrical Engineers, the Institution of Gas Engineers, and the National Physical Laboratory. Each National Committee is entitled to send ten delegates to the meetings of the International Commission. Countries in which a National Committee has not been formed may send representatives through any technical Gas or Electrical Society, or failing the existence of such societies, representatives may be nominated by Gas and Electric Lighting Companies. An Executive Committee is formed which is responsible for the affairs of the Commission. Voting at the international meetings is carried out by countries, and in order to be considered an official resolution of the International Commission, such resolution must receive a four-fifths majority of the countries taking part in the voting. It is provided that regular international meetings shall take place every three years.

8. There have been two important "*Conférences Internationale des Éphémérides Astronomiques*," one in 1896, which established greater uniformity in the adopted constants, such as that of the solar parallax and aberration, and one in 1912, which arranged for collaboration in different countries.

9. *The International Meteorological Conference and Committee.*—Beginning with 1891, the Directors of the Meteorological Institutes and Observatories of different countries have met periodically in "Conference" normally every ten years. The functions of the Conference are to propose measures of co-operation likely to prove helpful to the development of meteorology, to bring about uniformity of ideas, and to foster good relations between the workers of different countries. The Conference appoints, when it deems necessary, Commissions with independent powers to promote the study of special subjects. In addition to the purely meteorological Commissions appointed by the Conference, there were, at the outbreak of the war, five others concerned respectively with (*a*) Scientific Aeronautics, (*b*) Terrestrial Magnetism, (*c*) Radiation, (*d*) Solar Physics, and (*e*) the Application of Meteorology to Agriculture.

The Conference nominates a "Committee" to promote its objects during the interval of its meetings. The functions of the Committee are to give effect to the resolutions adopted at the previous Conference and to prepare for the next. The International Meteorology Committee is the organising body. It consists at present of seventeen members, who are all Directors of independent Meteorological Services.

The Meteorological Conference and Committee are unofficial bodies, but the Conference succeeded the official congresses of 1873 and 1879, and it acquires to some extent an official character by the circumstance that the heads of the Meteorological Services are Government officials. Its indefinite status diminishes to some extent its authority. Uniformity in the conduct of observations and the manner of reduction is of primary importance; but where there is, at the same time, a strong divergence of opinions, as in the case of hygrometry or terrestrial magnetism, the committees have so far not led to a satisfactory understanding. A certain amount of overlapping with other bodies has also been unavoidable.

10. *The International Solar Union* is another example of an association of scientific bodies carrying on effective work without official sanction or recognition. Of the twenty-one bodies composing it twenty are scientific societies. Of these, three are domiciled in the United States, three in France, two each in Great Britain, Italy, Spain, and Germany, one each in Austria, Canada, Holland, Russia, Sweden, and Switzerland. The list is completed by the Meteorological Committee, inself an international body. Meetings are held every three years, and the business in the meantime is carried out by an Executive Committee of three members only. Of these, one is nominated by the International Association of Academies—an arrangement suggested by the Solar Union itself, in order to secure a closer connexion between different branches of international work. There is no President, and the secretarial work is done by the Chairman of the Executive Committee. At the beginning of each meeting the Chairmen for different days are selected, generally from the country in which the meetings take place. Each Sub-Committee appointed for the investigation of special problems has its own Chairman and Secretary, and practically forms an independent body. This constitution has worked very well, the main difficulty being the absence of any provisions with regard to finance. But this has been overcome by voluntary donations.

So far as fundamental measurements are concerned, the Solar Union has, by means of its members working independently in different countries, determined secondary standards of wave-length spread over different parts of the spectrum. It has also, through a number of Committees, investigated questions relating to solar radiation, sunspot spectra, and solar rotation. Lately it has been led to exceed the limits indicated by its title, and now includes the whole stellar system in its purview. As a first step in this direction, it has appointed a Committee on the classification of stellar spectra.

11. *The "International Telegraphic Union"* is an institution having its "Bureau" at Berne, and is maintained by subscriptions from the States adhering to the Union. Occasional conferences are held which lead to "Conventions," of which a number are in force. The Bureau issues a monthly bulletin—*La Journal Télégraphique.*" The Union seems to be an official rather than a scientific body, the delegates of the conferences being selected from the clerical staff of the Telegraph Office, at any rate so far as Great Britain and its Colonies are concerned.

12. *Agreements on Wireless Telegraphy* have been made at international conferences specially called for the

purpose. No formal union or arrangement for regular meetings seems to exist.

13. *Bureau International de l'Heure.* —At an International Conference summoned by the "Bureau des Longitudes" of Paris in 1912, the following resolutions were passed:—

"1. Il est utile de chercher à réaliser l'unification de l'heure."

"2. L'heure universelle sera celle de Greenwich."

"3. Il sera utile de créer une Commission Internationale de l'Heure."

A provisional Committee was formed to give effect to the last of these resolutions, and statutes were prepared in which the objects of the International Commission were defined as follows:—"To unify the 'hour' by radio-telegraphic signals or otherwise whether for the purpose of scientific objects of high precision, or to supply the ordinary needs of navigation, meteorology, seismology, railway traffic, the postal and telegraphic services, public administration, watch-makers, private individuals, &c.

An International Bureau was to be established providing for scientific assistants charged with the conduct of special researches.

The cost was to be divided between the States forming the Union either through their Governments or some scientific body. The proposed statutes were submitted to the meeting of the International Association of Academies held in 1913 at Petrograd, and received their unanimous support. The outbreak of the war prevented further action.

(To be continued).

NOTICES OF BOOKS.

From War to Work. By SAMUEL TURNER. London: Nisbet and Co., Ltd. 1918. Pp. xiii+109. Price 1s. 6d. net.

THE thoughts of men and women are eagerly and hopefully turning to the problems of reconstruction, and it is the obvious duty of the better educated part of the nation to devote time and energy to the consideration of their aims and wishes in this respect. The wide circulation of books such as this is to be warmly encouraged, and every business man, every employer of labour, and every thoughtful working man will be able to learn something from it. The author points out that the want of orderliness in our social life, the discord and disputes between Capital and Labour before the war, were all due to a lack of conscious aim, and the only way to bring about the much desired harmony is to educate the nation to the realisation of the necessity of aiming at doubling production. The author believes that general over production is impossible, though local and temporary gluts may occur. He thinks that we shall be saved from the results of our collective ineptitude only if our conception of the function of a Government radically alters. The people's business is to select its governors and instruct them in its wishes for increased production, more efficient transport, better power supplies, &c., and the function of the Government is then to make its plans in accordance with these wishes.

Monograph on the Constitution of Coal. By MARIE C. STOPES, D.Sc., Ph.D., and R. V. WHEELER, D.Sc., London: Published for the Department of Scientific and Industrial Research by His Majesty's Stationery Office. 1918.

THE authors of this monograph have aimed at assisting in the elucidation of the problem of the actual structure of a bituminous coal, and have brought together and summarised all the important work which has been done on the subject, thus producing a very comprehensive review. The action of solvents on coal and the effects of its destructive distillation are first considered, and then the results obtained by examination under the microscope are discussed, the authors adopting the view that recognisable plant tissue plays a large part in the composition. A short summary is finally given of modern theories as to the nature of coal. It is shown that by the action of pyridine bituminous coal can be separated into an insoluble residue, consisting of what are known as α-compounds and an extract which is again separable into two parts by treatment with chloroform, the insoluble residue and extract being β- and γ compounds respectively. It is hoped that the examination of these separate portions may lead to a knowledge of the nature of coal, which appears to consist of a conglomerate of morphologically organised plant tissues, plant substances, devoid of morphological organisation, such as resin, and degradation products of plant tissue and cell contents. The monograph, which is provided with a very complete bibliography and excellent plates showing microscopical preparations of coal, is an important contribution to our knowledge of a subject of great economic and scientific importance.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

NOTE.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxvi., No. 11, March 18, 1918.

New Method of Preparing Monomethyl Aniline and Dimethylaniline by Catalysis.—A. Mailhe and F. de Godon.—When a mixture of the vapour of aniline with a slight excess of methyl alcohol is passed over alumina heated to 400—430° a mixture of mono and dimethyl anilines is obtained, which contains only traces of aniline. If methyl alcohol is again added and the process is repeated all the monomethyl derivative is converted into dimethyl aniline. After a certain time the alumina becomes yellow and then brown and its catalytic power is slightly diminished. On calcination it again turns white and recovers its activity. In this new method of preparing the monomethyl derivative the aniline need not be very pure, but may contain water, and the methyl alcohol need not be freed from acetone. The use of autoclaves, compressed air, &c., is also avoided, and labour is reduced to a minimum.

Action of Hydriodic Acid upon Cinchonine and its Isomers: Cinchoniline, Cinchonigine, and Apocinchonine.—E. Léger.—The four bases prepared by the action of hydriodic acid upon cinchonine and its isomers resembles one another in physical properties. When heated to between 153° and 156° they soften and undergo decomposition. The dichlorhydrates and dinitrates are obtained by adding to the moist hydroiodo base an excess of HCl or HNO_3 suitably diluted. The dichlorhydrates form pale yellow prisms, the rotatory power of which the author has examined. He finds that the compounds may be divided into two groups, according to their rotatory power corresponding with the groups of dibromates of the hydrobromo bases.

No. 12, March 25, 1918.

Determination of Tantalum in Alloys with Iron.—M. Travers.—The chief difficulty in determining tantalum arises from the presence of silica in the precipitate of tantalic acid. Separation by hydrofluoric acid is only approximate, 4 to 5 per cent of the tantalic acid possibly being volatilised with the silica. A satisfactory separation can be effected by volatilising the tantalic acid in a current

of gaseous hydrochloric acid at a temperature of 900°. The operation takes several hours, and must be continued till the weight is constant, and the purity of the silica is tested by volatilisation with hydrofluoric acid. For the analysis of a steel which can be attacked with aqua regia the tantalic acid is separated by two successive evaporations. The precipitate obtained contains silica and a little iron oxide. In the case of alloys which are not affected by acids they must first be fused with anhydrous sodium sulphite and the mass then taken up with acidulated water. The impure tantalic acid is fused with pure potash, the fused mass is taken up with water so as to separate the iron, and the solution is acidified with very dilute sulphuric acid. After boiling for an hour all the tantalic acid is precipitated with a small quantity of silica. It is weighed, and the silica is then determined as described above. If the alloy contains chromium a little peroxide of sodium is added to the potash, so as to yield chromic acid. If tungsten is present it is separated, after precipitation by dilute acid, by washing the precipitate with a large excess of ammonia solution. Nitric acid can be separated by the same method.

MISCELLANEOUS.

Lectures in Industrial Administration.—In our issue of March 1 (CHEMICAL NEWS, cxvii., 105) attention was directed to the efforts made by the Manchester College of Technology to deal with this subject. In our Advertisement columns for this issue will be found an announcement of the Lectures. The Council also invite applications for appointment to the Lectureship.

Oil and Colour Chemists' Association.—An Association of Chemists engaged in the Oil and Colour and Allied Trades has been formed for the purpose of considering and discussing the many complex points which are continually met with in the course of their work. The need for this Association has been felt for a long time, and the work undertaken by the chemists of the paint trade on the linseed oil substitution products has been the foundation on which this Association has arisen. A considerable measure of success has been accorded to the Society since its inauguration, and it is hoped that as the need is realised and the advantages of the Association are fully appreciated, all chemists engaged in the allied industries will become members. The first President of the Association is Dr. F. Mollwo Perkin, Ph.D., F.I.C., F.C.S., and an administrative Council has been elected, who together with Dr. F. M. Perkin are doing everything they can to make known and increase the usefulness of the Association. The Secretary, H. A. Carwood, 53, Groombridge Road, London, E. 9, will be pleased to hear from prospective members.

BATTERSEA POLYTECHNIC
Battersea Park Road, S.W. 11.

Principal—F. H. NEWMAN, M.A., Ph.D.
Head of Chemical Department—J. WILSON, M.Sc., F.I.C.
Chemical Engineering—H. GRIFFITHS, B.Sc., A.R.C.S.

A Course of Twenty-five LECTURES and LABORATORY CLASSES will be held on Monday evenings, commencing MONDAY, NOVEMBER 18. Fee 15s. Additional Practical Work on other evenings (except Thursday) if desired, Fee 10s. Lectures, 7 to 8; Laboratory, 8 to 9.30.
The Lectures will deal with the principles involved in the DESIGN, ERECTION, and WORKING of MODERN CHEMICAL PLANT, and the economic aspect of Chemical Manufacture.
The *Practical Work will deal with the Testing of Materials, the* Determination of Chemical Engineering data, &c.
For further details apply to the SECRETARY.

TO comply with Regulation 8 (b) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or *already engaged on Government work will be* engaged."

Chemist, B.Sc., London (Hons. in Chemistry, seeks Research appointment with large manufacturing firm.—Address, G. L., CHEMICAL NEWS Office 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist (Hons. B.Sc. Chemistry), with Technical Analytical and Research experience, requires Post.—Address, S., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

CHEMICAL ASSISTANT.—Well qualified Junior wanted in the Laboratory of a Manufacturing business in Limehouse. State salary and give references.—Address, "Limehouse," *CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street London, E C. 4.*

Metallographist required for Steel Works. experience in Physico-Chemical Measurements and Thermochemical calculations is desirable. State age and qualifications.—Address, C. W., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, Assistant Chemist with experience in the analysis of Iron, Steel, and Non-ferrous Alloys, for large Works in the North of England. No one at present engaged on Government work need apply.—Write, stating age, experience, and wages required to nearest Employment Exchange, quoting No. A 6182.

Works Analytical Chemist required. One conversant with Soap Manufacture, Nicotine Extractions, and Agricultural and Horticultural Preparations. State full particulars and salary required.—Address, W. A., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

DUTCH FIRM, *well introduced to all manu*factures in Holland, ask the REPRESENTATION of TECHNICAL and CHEMICAL PRODUCTS for Holland. Bank references.—Address, L. G. B. A., CHEMICAL NEWS Office, 16, New*castle Street, Farringdon Street, London, E.C. 4.*

Wanted, good Analytical Balance, also Refractometer, Polarimeter, Viscometer, and Flash Point apparatus.—Address, "Apparatus," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, BECKMAN THERMOMETER. Please send particulars to "Thermometer," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, POLARIMETER. Anyone wishing to dispose of one please send particulars of the instrument to "Polarimeter," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

APPOINTMENTS REGISTER.

A Register of FELLOWS and ASSOCIATES of the INSTITUTE OF CHEMISTRY who are available for Appointments is kept at the Offices of the Institute. Applications for the services of Chemists should be forwarded to THE REGISTRAR, The Institute of Chemistry, 30, Russell Square, London, W.C. 1.

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In consequence of the "No Returns Order" of the Government, readers of the "Chemical News" are requested to ensure a regular supply of the paper by placing an order with their Newsagent.

THE CHEMICAL NEWS

Vol. CXVII., No. 3056.

(STUDENTS' NUMBER).

UNIVERSITIES AND COLLEGES.

UNIVERSITY OF LONDON.

Candidates for any Degree in this University must either have passed the Matriculation Examination in this University, or be admitted under the Statute which provides that the Senate may admit graduates of or persons who have passed the examinations required for a degree in other Universities approved by it. This and all other Examinations of the University, together with the Prizes, Exhibitions, Scholarships, &c., are open to Women upon exactly the same conditions as to Men.

There are three Examinations for Matriculation in each year; commencing on the second Monday in September, January, and June or July, as may hereafter be determined.

Every Candidate for the Matriculation Examination must apply to the Principal for a Form of Entry on or before August 20, which must be returned fourteen days before the commencement of the September Examination; or must apply for a Form of Entry on or before November 25, which must be returned on or before December 1, for the January Examination; or must apply for a Form of Entry on or before April 25, which must be returned on or before May 1, for the June (or July) Examination; accompanied in each case by the proper Fee, and by a Certificate showing that the Candidate will have completed his Sixteenth Year on or before January 14 for the January Examination, July 31, the end of the Secondary School Year, for the June Examination, and September 15 for the September Examination.

Every candidate entering for the Matriculation Examination must pay a Fee of £2.

Intending Students (Internal and External) should obtain the "Regulations and Courses" from the Registrar, University of London, South Kensington, S.W.

Several valuable Scholarships and Exhibitions are available to students.

UNIVERSITY OF OXFORD.

Waynflete Professor of Chemistry—W. H. Perkin, M.A., F.R.S.

Every Student must reside in one or other of the Colleges or Halls, or in licensed lodgings, for a period of three years. Students of Chemistry can obtain the degree of B.A. by passing preliminary examinations in Arts and in Science, and a final Honour examination in Chemistry. Chemistry may also be taken as part of the examination for a Pass degree. Graduates of other Universities and other persons suitably qualified can obtain the degree of Bachelor of Science after an approved course of study or research and two years' residence.

University Laboratory.—The fee for students working in the Laboratory for three days in the week during the Term is £3; for students working every day, £5.

There are also laboratories which specialise in different parts of the subject:—*Physical Chemistry*, Balliol and Trinity College Laboratory. *Inorganic Chemistry*, Christ Church Laboratory. *Quantitative Analysis*, Magdalen College Laboratory, Jesus College Laboratory. *Organic and General Chemistry*, Queen's College Laboratory.

Numerous Scholarships, usually of the value of £80 per annum and tenable for four years, are offered every year by the various colleges. They are awarded after a competitive examination in the various branches of Natural Science.

More detailed information may be obtained from the Examination Statutes; the Student's Handbook to the University; and from the professors and college tutors.

UNIVERSITY OF CAMBRIDGE.

Professor of Chemistry—William J. Pope, M.A., F.R.S.

Jacksonian Professor of Natural and Experimental Philosophy—Sir James Dewar, M.A., F.R.S.

Goldsmiths Reader in Metallurgy—Charles T. Heycock, M.A., F.R.S.

The Student must enter at one of the Colleges or Hostels, or as a Non-collegiate Student, and keep terms for three years by residence in the University. He must pass the previous examination in Classics and Mathematics, which may be done in any term of residence or before commencing residence. He may then proceed to take a Degree in Arts, either passing the ordinary examinations or B.A., or going out in one of the Honour Triposes.

A graduate of another University may be admitted as a Student of Research, and obtain a degree after two years' residence in the University, by presentation of a thesis describing original research.

Facilities for research work are provided both in the Chemical Laboratories and in the Metallurgical Laboratories.

The scholarships range in value from £20 to £100 a year. Scholarships, or Exhibitions, are given for Natural Science at the several Colleges; the dates of the examinations vary, but are always fully advertised.

The Chemical Laboratories of the University are open daily for the use of the Students. The Demonstrators attend daily to give instruction. A list of the lectures and practical courses is published annually, in June, in a special number of the *Cambridge University Reporter*, which may be had from the Cambridge Warehouse, in Paternoster Row, or through any bookseller.

Non-collegiate Students are allowed to attend certain of the College Lectures and all the Professors' Lectures, and have the same University status and privileges as the other Students. Full particulars may be obtained by forwarding a stamped directed envelope to the Assistant Registrary, Cambridge, from the *Cambridge University Calendar*, or from the "Students' Handbook to Cambridge."

UNIVERSITY OF DUBLIN.

Trinity College.

Professor of Chemistry—Sydney Young, D.Sc., F.R.S.

Professor of Applied Chemistry—Emil A. Werner, Sc.D., F.C.S., F.I.C.

Demonstrator—W. C. Ramsden, F.C.S.

Junior Demonstrator—G. K. Carpenter.

The general Quantitative and Research Laboratories include working accommodation for about 130 Students. The Laboratories will open on October 1st. Lectures will commence on November 4th.

The Laboratories and the Lectures of the Professor of Chemistry can be attended by Students who do not desire to reside in the University or proceed to its Degrees.

The full Course of General and Analytical Chemistry occupies three years, but a Student is free in his third year to devote most of his time to a special department of Pure or Technical Chemistry. Students can enter for any portion of the Course. The Lectures delivered are:—

1. *Inorganic Chemistry and Chemical Philosophy.*—Elementary, first year; Advanced Inorganic Chemistry, second year; Physical Chemistry, third year.
2. *Organic Chemistry.*—General, second year; advanced, third year.
3. *Metallurgy.*—A Course for Engineering and Technical Students.
4. *Agricultural Chemistry.*—Theoretical and Practical Courses.

The Laboratories are open every day from 10 to 5 o'clock (except Saturdays, when they close at 1 o'clock).

The Summer Course of Practical Chemistry for Medical Students begins early in April and terminates about the middle of June.

A special course for Dental Students will be given.

The University of Dublin grants the Degree of Doctor of Science to graduates of Master's standing whose in-

dependent researches in any branch of Science are of sufficient merit.

The University also grants the Degree of Bachelor of Science to graduates who have obtained Moderatorship or an Honours Degree equivalent to Moderatorship and have devoted a year to research in the University Laboratory.

Prizes in Chemistry and Physics are given at the October (Arts) Entrance Examination, and also at the Terminal Examinations of the Junior and Senior Freshmen Years.

Similarly, two Science Scholarships will be obtainable by Undergraduates, and tenable for five years. The Foundation Scholars receive £20 per annum, they have free commons, and their chambers for half the charge paid by other students; their tutorial fees are at one-fourth the usual rates.

KING'S COLLEGE.

(University of London).

Professors—Sir Herbert Jackson, K.B.E., F.R.S., &c. (Daniell Professor), and A. W. Crossley, C.M.G., Ph.D., F.R.S., &c.

Assistant Professor—P. H. Kirkaldy, F.I.C., &c.

Lecturers and Demonstrators—S. W. Collins, B.Sc., L. E. Hinkel, B.Sc., H. D. Elkington, B.Sc., H. W. Cremer, B.Sc., A. H. Jay, B.Sc., Mary Esslemont, B.Sc., and A. Weston.

The Academical Year consists of Three terms. The days fixed for the commencement of Terms in 1918-1919 are Oct. 2, Jan. 15, and April 30.

The general Courses of Lectures on Chemistry deal with the nature and scope of the subject and the principles involved, in relating to one another the experimental facts, shown as illustrations of the properties of the elements and their chief compounds. The non metallic elements are first treated of, as demonstrating most clearly the characters of the interactions between the different kinds of matter, and as affording the best opportunity of classifying the main groups of compounds met with, when dealing with the inorganic branch of the subject. The metallic elements and their compounds are then discussed, and this part of the Course is completed with a *résumé* in which the connected relations of the properties of the elements are described. The latter portion of the Course embraces in the same manner a study of the principles and properties of the carbon compounds which are examples of the main groups of organic substances. Class Examinations are held from time to time during the Session.

Experimental and Analytical Chemistry in the Laboratory.—The object of this Class is to afford to Students who are desirous of acquiring a knowledge of analysis, or of prosecuting original research, an opportunity of doing so under the superintendence of the Professor and Demonstrator; Students may enter, upon payment of extra fees, at any time except during the vacation, and for a period of one, three, six, or nine months, as may best suit their convenience. The laboratory hours are from ten till five daily, except Saturday.

In addition to the Laboratory Fee, each Student defrays the expenses of his own experiments. The amount of this expense, which is comparatively trifling, is entirely under his own control.

For fuller details the separate Syllabuses provided for each class should be consulted.

War Students.—Students who (i.) have served in His Majesty's Forces, (ii.) have undertaken other service approved by the University in connection with national defence, or (iii.) have been interned as civilian Prisoners of War, will be entitled to present themselves for Intermediate and Final Examinations under special conditions. Students included in the categories enumerated above will be termed "War Students." For full particulars application should be made to the Secretary of the College.

UNIVERSITY COLLEGE.

(University of London).

Professors—J. Norman Collie, Ph.D., F.R.S. (Organic Chemistry); F. G. Donnan, M.A., F.R.S. (Inorganic and Physical Chemistry).

Assistants—S. Smiles, D.Sc.; Katharine A. Burke, B.Sc.; R. E. Slade, D.Sc.; W. B. Tuck, D.Sc.; Irvine Masson, M.Sc.; H. Terrey, B.Sc.

The Session is divided into three Terms, as follows:—First Term, from September 30 to December 18; Second Term, from January 14 to March 28; Third Term, from April 29 to July 3.

Introductory Course of Inorganic Chemistry.

Tuesday and Thursday, at 11. Practical, Thursday, 2 to 3.30, or 3.30 to 5. Fee, £10 10s.

A course of Elementary Inorganic Chemistry, adapted to the requirements of students of Engineering.

Junior Course of Inorganic Chemistry.

An Introduction to the Principles of Inorganic Chemistry. Special attention will be paid to general points of view, and to the application of physico chemical laws and methods.

First and Second Terms: The Class meets on Mondays, Wednesdays, Fridays, and Saturdays, at 9, for Lectures, Examinations, and Exercises.

Third Term: Lectures will be given on Mondays and Fridays at 9, and Wednesdays at 11.

Fees: Course, £7 7s.; First or Second Terms, £4 4s.

A Practical Class will meet throughout the Session.

Senior Course of Physical Chemistry.

Tuesday and Thursday at 9.

A general Course on Physical Chemistry and its applications. Fee:—Course £5 5s.

General Course of Organic Chemistry.

Monday and Wednesday at 12, Thursday at 3.

Fees:—For the Course, £6 6s.; for a Term, £2 12s. 6d.

An Advanced Course will be held twice a week throughout the Session for those engaged in prosecuting research in Organic Chemistry. Monday and Friday at 11. Fee £5 5s.; Term, £2 2s.

Practical Classes.

Practical Classes in Inorganic and Organic Chemistry are conducted by the Assistants.

Laboratories of General and of Organic Chemistry.

The Laboratories are open daily from 9 a.m. to 5 p.m. Saturdays excepted, from October until the middle o July, with a short recess at Christmas and at Easter.

Fees: for the Session, £26 5s.; six months, £18 18s. three months, £10 10s.; one month, £4 4s.

Three specified days a week:—for the Session, £15 15s. six months, £11 11s.; three months, £6 6s.; one month £2 12s. 6d., exclusive of expense of materials. Student may enter at any period of the Session.

When accompanied by, or preceded by, attendance o the Lectures and Practical Classes in Inorganic an Organic Chemistry, the Laboratory Courses quali Students in the application of Chemistry to Manufactures Metallurgy, Medicine, or Agriculture, &c.

There is also a Chemical Library containing the chie Journals and Standard Works on Chemistry.

Certificates of Honour are granted to competen Students on the work done during the Session. Severa valuable Scholarships are available to students.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

Emeritus Professors—Sir W. A. Tilden, D.Sc., F.R.S and Sir T. E. Thorpe, C.B., F.R.S., &c.

Professor and Director of the Chemical Laboratories.—H. Brereton Baker, C.B.E., D.Sc., F.R.S., &c.

Professor of Chemical Technology and Fuel Chemistry—W. A. Bone, F.R.S.

Professor of Organic Chemistry—J. F. Thorpe, C.B.E F.R.S.

Professor of Physical Chemistry—J. C. Philip, O.B.E., M.A., D.Sc.

Assistant Professor—B. Mouat Jones, M.A., D.S.O.

The Imperial College of Science and Technology, incorporated under the Royal Charter of July 8, 1907, is an institution or group of associated colleges with its principal seat at South Kensington.

The purposes of the Imperial College are to give the highest specialised instruction, and to provide the fullest equipment for the most advanced training and research in various branches of science, especially in its application to industry; and to do all and any of such things as the Governing Body consider conducive or incidental thereto, having regard to the provision for those purposes which already exists elsewhere.

For these purposes, the Governing Body, subject to the provisions of the Charter, are to carry on the work of the Royal College of Science, and the Royal School of Mines, and may establish Colleges and other Institutions or Departments of Instruction. Any Institution or Department so established, and, subject to the conditions of the Charter, the Central Technical College of the City and Guilds of London Institute, are to be integral parts of the Imperial College; and the Central Technical College is to be called and known in future as the City and Guilds College.

The Charter further provides that the Imperial College shall be established in the first instance as a School of the University of London. Students of the Imperial College who have matriculated at the University of London may therefore proceed to the Science degree of the University as "Internal Students."

Attention is particularly directed to the conditions of admission and to the extended facilities for Research Work.

The ordinary courses of instruction are planned so as to extend over four years, and are generally similar for all divisions during the first year, and to a less extent during the second year, after which they are specialised according to the particular course which the student is taking.

The following Diplomas are awarded to Students of the several constituent Colleges:—

The Diploma of the Imperial College of Science and Technology (D.I.C.) for advanced study or research in Pure or Applied Science.

The Associateship of the Royal College of Science (A.R.C.S.) in one or more of the following divisions:—Mechanics, Physics, Chemistry, Botany, Zoology, Geology

The Associateship of the Royal School of Mines (A.R.S.M.) in one or more of the following divisions:—Metallurgy, Mining.

The Associateship of the City and Guilds Institute, (A.C.G.I.) in Engineering (Civil and Mechanical), Engineering (Electrical).

Twelve entrance scholarships are given in September each year, and post graduate scholarships are available for enabling fourth and fifth year students to complete their courses. Three Research Fellowships, founded by Mr. Otto Beit, of £150 a year, tenable at the Imperial College, are offered annually to post graduate students of this College, as well as to graduates of other Universities.

Full details can be obtained from the College Calendar, published by Eyre and Spottiswoode (or through any bookseller), price 6d.

THE SCHOOL OF PHARMACY OF THE PHARMACEUTICAL SOCIETY OF GREAT BRITAIN.

Professor—Pharmaceutics, Henry G. Greenish, F.I.C., F.L.S. (Dean); Lecturers—Chemistry, C. E. Corfield, A.I.C.; Botany, J. Small, M.Sc.

A Course of Lectures on Physical, Inorganic, and Elementary Organic Chemistry, Botany, Materia Medica, and Pharmacy commences in October and terminates at the end of June. An Advanced Course of Lectures begins in October and extends to the end of March. These Lectures are adapted to the requirements of Pharmaceutical and Medical Students, and also of those who are proceeding to degrees at the University of London, or who are preparing for the examinations of the Institute of Chemistry.

Entries may be made for single classes. Certificates of attendance at the Lectures and Practical Work in Chemistry and in Botany are accepted as evidence of scientific training by the Institute of Chemistry in connection with the Examinations for the Associateship. Certificates of attendance at the Lectures and Practical Work in Chemistry are accepted by the Conjoint Board of the Royal Colleges of Physicians and Surgeons, as well as by other examining bodies. Certificates of attendance at the Course of Pharmacy are also accepted by the Conjoint Board, and at the Courses of Pharmacy and Materia Medica by the University of London for the Second Examination for Medical Degrees, Part II.

Prospectuses and further information may be obtained from the Dean of the School, 17, Bloomsbury Square, London, W.C.

UNIVERSITY COLLEGE OF WALES, ABERYSTWYTH.

University of Wales.

Professor—A. Findlay, M.A., D.Sc. (Aberdeen), Ph.D. (Leipzig), F.I.C.

Lecturer and Demonstrator—T. Campbell James, M.A., Trinity College, Cambridge, D.Sc. (Wales), F.I.C.

Assistant Lecturer and Demonstrator—Vacant.

Lecture Assistant—(Vacant).

Student Assistant—(Vacant).

Lecturer in Agricultural Chemistry—J. Jones Griffith, B.Sc. (Wales).

The College is open to men and women students above the age of sixteen years. The Session commences on Oct. 1st, on which day all Students will be expected to meet the Professors in the Examination Hall of the College.

Lecture Courses.—(1) Intermediate Science Course; four lectures weekly throughout the Session. (2 and 3) B.Sc. Courses; A, three lectures weekly on Organic Chemistry; B, three lectures weekly on General and Physical Chemistry. (Courses A and B will generally be given in alternate Sessions; for 1918-1919, Course B). (4 and 5) Courses in Agricultural Chemistry. For students in their first year, 3 lectures, and for those in their 2nd year, 2 lectures weekly during the Michaelmas and Lent terms.

Laboratory Courses.—The Laboratories are open daily from 9 a.m. to 1 p.m. and from 2 to 6 p.m., Saturdays 9 a.m. to 1 p.m. Regular Courses of practical work, suitable for the B.Sc. degree of the Universities of London and Wales, or for the Associateship of the Institute of Chemistry, can be followed. Facilities are given for Students wishing to undertake research work. Special Courses will be arranged for those who intend to follow Medicine or Pharmacy, or any one particular branch of Applied Chemistry, always provided that such Students possess the requisite knowledge of Theoretical Chemistry. The hours will be arranged, as far as possible, to suit the requirements of the individual Student.

The College is recognised by the University of Edinburgh and the Royal University of Ireland, and by the Colleges of Physicians and Surgeons of England, Scotland, and Ireland as an institution at which the instruction necessary for their respective Diplomas in Medicine, in Chemistry, Physics, and Biology may be given. One year for graduation in Medicine and two years for graduation in Science may be spent at Aberystwyth.

Fees.—The Fee for the whole Session, if paid in advance, is £17. This composition fee enables the Student to attend any or all the Classes and Laboratories of the College.

Scholarships and Exhibitions varying in value from £10 to £40 per annum will be offered for competition at examinations which commence on September 19, and exhibitions are awarded at the end of the Session on the results of the class examinations.

Intending Students requiring further information are recommended to write to the Registrar for a copy either of the General Prospectus or of one of the Special Prospectuses issued for the Agricultural and Normal Departments.

UNIVERSITY COLLEGE OF NORTH WALES, BANGOR.

A Constituent College of the University of Wales.

Chemistry.—Professor, K. J. P. Orton, M.A., Ph.D., F.I.C. Assistant Lecturers and Demonstrators, J. O. Hughes, B.Sc., Sybil M Leslie, M.Sc., Lecturer in Agricultural Chemistry, H. E. Jones, B A., B.Sc.

Physics.—Professor, E. Taylor Jones, D.Sc. Assistant Lecturers and Demonstrators, A. H. Ferguson, M.A., D.Sc., and W. E. Williams, B.Sc.

The Session opens October 1st, 1918. All regular classes are open to men and women students above the age of 16 years. The following Courses of Lectures will be given.

Intermediate Course.—Inorganic Chemistry and Elementary Physical Chemistry. Fee for the Session, £5.

B.Sc. Course.—Inorganic Chemistry. Fee for the Session, £3 15s. Advanced Lectures on Organic Chemistry, £1 5s. Physical Chemistry, £1 5s.

Agricultural Chemistry.—Fee, £2 10s.

Laboratory Courses.—The laboratory is open on five days of the week from 10 a.m. to 5 p.m. for instruction in Chemical operations and in the Application of Chemistry to Medicine and the Industrial Arts. Fees: six hours per week, £1 1s. per Term; twelve hours, £2 2s.; Composition Fee for all Lectures and Laboratory Classes of the Science Degree Course taken in one year, £16.

The College Courses are arranged with reference to the Degree Courses of the University of Wales (of which the College is one of the Constituent Colleges). The Courses in Science are also suited to the requirements of Students preparing for the Science Degree Course of the University of London.

The Chemistry, Botany, Zoology, and Physics Courses are recognised for Medical graduation in the Universities of Edinburgh and Glasgow, and by the Conjoint Boards of the Royal Colleges of Surgeons and Physicians, and students can make one *Annus medicus* at the college. *Students are prepared for the First Examination of the* Universities mentioned, the First Examination for Medical Degrees of the University of London, and of the Conjoint Board of the Royal Colleges of Surgeons and Physicians. The Science Courses are recognised for part of the science degree course of the University of Edinburgh.

UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE, CARDIFF.

Professor of Chemistry—C. M. Thompson, M.A., D.Sc., F.C.S.

Assistant Professor—E. P. Perman, D.Sc., F.C.S.

Lecturer to Medical Students and Demonstrator—F. W. Rea, B.A , M Sc

Professor of Metallurgy—A. A. Read. D.Met., F I.C.

The Session commences October 8th and terminates on June 27th, and is divided into three terms.

The Junior Course (delivered during the Michaelmas term only) consists of about 30 lectures, and will cover the subjects prescribed for the Matriculation examinations of the University of Wales and the University of London.

The Intermediate Course consists of about 80 lectures; together with laboratory practice it forms the qualifying course for the Intermediate Examination of the University of Wales, and will cover the subjects required for the Intermediate Examination in Science (Part I.) of the University of London.

The Senior Course consists of about 80 lectures on Inorganic Chemistry.

A course on Organic Chemistry will be given in the Session 1919-1920.

In the laboratory each student works independently, so that the course of study may be adapted to the requirements of the individual. Hours, 9 to 1 and 2 to 5; Saturday, 9 to 1. Fees—Six hours per week, £4 per session; eight per week, £6 6s. per session; twelve hours or more per week, £8 8s. per session.

Registered medical students can prepare for the Intermediate M.B. Examination of the University of London, and spend three out of their five years of medical study in Cardiff. Medical students preparing for a Conjoint Board Surgical and Medical Diploma, or for the Diploma of the Society of Apothecaries, can spend two years in Cardiff. For further information see the prospectus of the Faculty of Medicine, which may be obtained from the Registrar.

Students by making a payment of £16 at the commencement of each session may compound for all fees for the whole session.

At the entrance examination in April, and the annual examination in June, several scholarships and exhibitions are awarded. Great importance is attached to special excellence in one subject.

The College Prospectus, and also further information as to scholarships, may be obtained from the Registrar.

A special prospectus is issued concerning courses of study for diplomas in engineering, mining, and metallurgy.

A Hall of Residence for Women Students is attached to the College.

UNIVERSITY OF BRISTOL.

Department of Chemistry.

Alfred Capper Pass Professor of Chemistry—Francis Francis, D.Sc., Ph.D., F.I.C.

Lecturers—O. C. M. Davis, B.Sc., D.Sc., M.B., F.I.C., Capt. R.A.M C.; F. W. Rixon, M.Sc , PhD.

Lecturer in Physical Chemistry—James W. McBain, M.A., Ph.D., Capt. attached D.E.S., M. of Munitions.

Lecturer in Bio-chemistry—M. Nierenstein, Ph.D, D.ès Sc.

Lecturer in Hygienic Chemistry—Edward Russell, B.Sc., F.I.C.

Laboratory Steward—J. H. Sturgess (on active service).

The session commences on October 1.

The Department of Chemistry is situated in the new wing of the University Buildings in Tyndall's Park, and was opened on October 1, 1910. The Department provides accommodation for 200 students, and laboratories for work in specialised branches of Chemistry have been designed and equipped with apparatus of the most modern type. All the laboratories are supplied with electric wiring for experimental purposes, and currents of any desired voltage up to 250 volts at 50 ampères from dynamo or storage cells may be obtained throughout the Department. Higher voltages and currents are available in special laboratories, for Physical Chemistry and Electro-metallurgy. Special facilities are afforded to those who desire to carry out research or to study Chemistry as applied to the different processes employed in the arts and manufactures; and a laboratory for Bio-chemistry has been specially designed for the investigations of problems on Biological lines.

Day Lectures.

General Courses.—1. General Inorganic Chemistry—Three lectures per week during Session and Laboratory work. 2. General Organic Chemistry—Three Lectures per week during one Session and Laboratory work. 3. Physical Chemistry—Three Lectures per week for first Session, two Lectures per week for second Session, and Laboratory work.

The Laboratories are open daily from 9.30 to 5 except on Saturdays, when they are open for Senior Students only.

Courses for Graduation.—*Intermediate Science*—Course 1 and one day Laboratory per week. *Pass Degree*—Course 2 and 3, and at least one day Laboratory per week during two Sessions. The Chemical Society must be attended during the second and third years, and one or more of the Special Courses arranged for Honours Students. *Honours Degree*—Four year course, or three

in the case of those who already hold a Higher School Certificate. The last session is spent on research which is essential for all Honours Degrees in the Faculty of Science. During the first year in the Honours School Courses 2 and 3, and the second and third, Course 3, and one or more of the following Special Courses as directed, *e.g.*:—Organic Chemistry, Physical Chemistry, Mathematical Chemistry, Advanced Inorganic Chemistry, Applied Electro-chemistry, some part of Bio chemistry.

The meetings of the Chemical Society must be attended during each Session.

Colloquium.—A weekly Colloquium will be held by members of the Staff to discuss recent advances in the various developments of Chemistry. Honours Students attend, and others interested are invited to do so.

Extract from Regulations as Regards Fees.

1. Registration Fee 7s. for a single Course; £1 1s. shall cover a perpetual registration for any number of Courses.

2. Inclusive Fee for an entire curriculum for degree of B.Sc., whether "Pass" or "Honours," shall be £21 a year.

The Fees for separate Laboratory practice and instruction in the Faculty of Science shall be at the rate of £2 2s. per term for each day in the week for which admission in the Laboratories is sought, with a minimum of £3 3s. in each particular case.

The scale of fees for separate courses of lectures in the Faculty of Science may be obtained on application.

All communications to the University to be addressed to the Registrar. Information concerning Courses or Laboratory work in the Department of Chemistry may be obtained from the Professor.

The department of Experimental Physics includes various courses of lectures arranged progressively, and practical instruction is given in the physical and electrical laboratories. The Faculty of Engineering includes courses specially arranged for students intending to become civil, mechanical, electrical, or automobile engineers. Medical education is provided by the Faculty of Medicine of the University. Several Scholarships are tenable at the University.

MERCHANT VENTURERS' TECHNICAL COLLEGE, BRISTOL.

CHEMISTRY.

Professor—J. Wertheimer, B.A., D.Sc., F.I.C., F.C.S.

Lecturers—H. A. M. Burland, A.R.C.S.; Annie M. Herbert, B Sc.

Demonstrators—H D. P. Davies and W J. Gibbs.

Laboratory Steward—Mary R. Saunders.

Assistant in Chemical Laboratory—H. Hooper.

The following Evening Classes in Chemistry are held:—Preliminary Inorganic, Mondays, 7.10—9.15; Matriculation (Inorganic), Fridays, 7.10—9.50; Intermediate (Inorganic), Tuesdays, 7.10—9.50. They will begin on Monday, Sept. 30th, 1918.

UNIVERSITY OF BIRMINGHAM.

Professor—Percy F. Frankland, Ph.D., Sc.D., LL.D., F.R.S., F.I.C.

Assistant Lecturers and Demonstrators — Hamilton McCombie, M.A., Ph.D., B.Sc., A.R.C.S., A.I.C.; S. R. Carter, M.Sc.; A. Parker, D.Sc.; Wm. Wardlaw, M.Sc.; J. E. Coates, M.Sc.

Professor of Metallurgy—Thomas Turner, M.Sc., A.R.S.M.

The Session will be opened on October 1st, 1918.

The Chemical Department has hitherto been housed in the new University buildings at Bournbrook, but owing to those buildings having been taken over by the Military Authorities for use as a Base Hospital the classes during the coming Session will be arranged for at the Birmingham Municipal Technical School and the Mason College.

Lecture Courses.

First Year.—A. This part of the course is arranged (1) to give a full exposition of the general principles of Chemical Science, (2) for the systematic study of the properties of the more important elements and their compounds, and (3) to indicate the chief applications of Chemistry in the Arts and Manufactures. Three hours weekly during the Winter and Spring terms. Mondays, Wednesdays, and Thursdays at 9 30 a m. Fee, £5 5s. B. This part of the course includes an introduction to the study of Organic Chemistry, with a description of the properties, relations, and methods of preparation of the more important groups of Carbon Compounds. Three hours weekly during the Summer term. Mondays, Wednesdays, and Fridays, at 9 30 to 10 30 a.m. Fee, £1 11s. 6d.

Second Year. — *Advanced Organic Chemistry.*— This course extends over two years, and is divided into two parts:—(*a*) Carbon Compounds of the Fatty Series; (*b*) Aromatic and other Cyclic Compounds. Only one of these parts will be taken in each year. The class meets twice weekly by arrangement during the Winter and Spring terms. Fee, £2 2s. *Advanced Inorganic Chemistry.*— This course is devoted to the consideration of special branches of Inorganic Chemistry, and direction is also given as to the private reading which should be pursued by students. The class meets by arrangement once weekly during the Session. Fee, £1 1s.

Third Year.—A further Course in Advanced Organic Chemistry will deal with one of the above parts of the Course. The class meets two hours weekly by arrangement during the Winter and Spring terms. Fee, £2 2s. A Course on Physical Chemistry. Fee, £2 2s.

The class meets two hours weekly during the Winter and Spring Terms.

Fourth Year.—For students preparing for the B.Sc. degree with Honours in Chemistry.

Special Courses in General, Organic, and Physical Chemistry.

Practical Chemistry.

The instruction in Practical Chemistry Inorganic, Organic, and Physical) extends over four years in the case of the Honours Degree. The Laboratory will be open daily from 9 30 to 5, except Saturdays, when it closes at 1 p.m. Fees—

	All day.	Three hours per day.	Three hours per day; five days a week.	Three hours per day, three days a week.
	Guineas.	Guineas.	Guineas.	Guineas.
One Term ..	7	4½	4	3½
Two Terms .	13	8½	7½	5
Three Terms	18	12	11	6½

Special facilities are given to Advanced Students for the prosecution of original research.

Metallurgy.

There is a separate University department for Metallurgical students in which provision is made for instruction in assaying, &c.

Scholarships.

Priestley Scholarships.—Three Open Scholarships in Chemistry of the value of about £96 each are awarded annually in June.

Ascough Scholarship.—One Open Scholarship of the value of about £30 is awarded annually in July.

Bowen Scholarship.—One Open Scholarship in Metallurgy, value about £96, is awarded annually in June.

For particulars apply to the Registrar.

CITY OF BRADFORD TECHNICAL COLLEGE.

Principal—Prof. W. M. GARDNER, M.Sc, F.I C.

DEPARTMENT OF CHEMISTRY AND DYEING.

Professor of Chemistry and Dyeing—The Principal.

Assistant Professor of Chemistry—B. North, A.R.C.S., F.I.C.

Lecturers in Chemistry—L. L. Lloyd, Ph.D.; H. Middleton, M.Sc; A. Jackson, B.Sc.; E. Jones, B.Sc.

Lecturer in Physics—J. A Tomkins, A.R.C.S (Lond.).

Demonstrator in Physics—F. Harcourt, B.Sc.

Lecturer in Gas Manufacture—J. W. Roper.

Lecturer in Botany—J. Cryer.
Lecturer in Pharmacy—G. H. Etchells.
Lecturer in Biology—J. A. Fisher.

The following courses of instruction are provided—

I. *General Chemistry Course*, extending over four years, and including Lectures in Inorganic, Organic, and Technological Chemistry, Principles of Analysis, Technical Analysis, Electro-chemistry, Physical Chemistry, Physics, Mathematics, Mechanics, with Laboratory work in Chemistry and Physics.

II. *Chemistry and Dyeing Course*, extending over four years. Includes most of the above subjects, along with Lectures and practical work in Dyeing, Colour matching, &c. The practical laboratories include a completely equipped Practical Dyehouse and Finishing Rooms.

III. *Chemical Engineering*. Three years' course, preparing Students for positions in Chemical Works, Sewage Works, &c.

IV. *Sanitary Science*. One year's Course, recognised by the Sanitary Institute as preparing for their certificate examination. Subjects: Chemistry, Physics, Sanitary Engineering, Sanitary Law, Building Construction, Drawing, Physiology, and Bacteriology.

V. *Dyeing*. Special Courses for Graduates in Chemistry, and for Drysalters, Colour Merchants, &c.

VI. *Textile and Dyeing*. Arranged for those Students who desire to study the two subjects simultaneously.

VII. *First Professional Examination, Conjoint Medical Board (M.R.C.S., L.R.C.P.), London*.—Attendance at the College and College Certificates in Chemistry, Physics, and Biology are recognised by the Conjoint Boards for Medical Studies (London and Dublin) as a qualifying curriculum.

VIII. *General Pharmaceutical Course*. Prepares for the Minor, Major, and Assistants' Pharmaceutical Examinations. Each extends over two years on four half-days per week, and includes Chemistry and Physics, Botany, Biology, Materia Medica, Pharmacy, and Dispensing.

ROYAL AGRICULTURAL COLLEGE, CIRENCESTER.

CHEMICAL DEPARTMENT.

Professor—Prof. E. Kinch, F.C.S., F.I.C.
(Closed during the period of the war).

THE UNIVERSITY OF LEEDS.

Professor of Chemistry—Arthur Smithells, B.Sc., F.R.S.
Professor of Organic Chemistry—Julius B. Cohen, Ph.D., B.Sc., F.R.S.
Lecturer on Physical Chemistry—H. M. Dawson, D.Sc., Ph.D.
Lecturer in Analytical Chemistry—W. Lowson, B.Sc., F.I.C.
Assistant Lecturer and Demonstrator—W. H. Perkins, M.Sc.
Demonstrator in Organic Chemistry—P. H. Dutt, M.A., M.Sc.
Temporary Demonstrator—F. W. Turner, B.Sc.

Lecture Courses.

1. General Course of Chemistry.—Monday, Wednesday, and Friday, at 11.30 a.m. Fee for the Course, £5 10s.

2. Advanced Inorganic Chemistry. — (A) Monday, Wednesday, and Friday, at 9.30 a.m. Fee, £4 10s.

3. Advanced Inorganic Chemistry. — (B) Tuesday, Thursday, and Saturday, at 9.30 a.m. Fee, £4 10s.

4. Organic Chemistry. — Tuesday, Thursday, and Saturday at 11.30 a.m. Fee £4 10s.

5. Honours Courses.—(*a*) Organic Chemistry: Monday, Wednesday, and Friday at 11.30 a.m.; fee, £4 10s. (*b*) History of Chemistry: Monday, Wednesday, and Friday at 9.30 a.m. in the First Term; fee, £2 5s. (*c*) Physical Chemistry: Three hours a week at times to be arranged; fee, £4 10s. (*d*) Electro-chemistry: Tuesdays at 9.30 a.m.; £2 10s.

6. Chemistry of Food and Drugs.—Special class during the second term for Students taking Final Examination of the Institute of Chemistry in Branch E (Food and Drugs). £3 3s.

Laboratory Courses.

The University Laboratory will be open daily from 9 a.m. to 1 p.m., and from 2 to 5 p.m., except on Saturdays, when it will close at 1 p.m.

Fees for the Session—£3 per half day of three hours per week.

Practical Course in Sanitary Chemistry.—Tuesdays and Thursdays from 2 to 5 in the Second and Third Terms, Fee, £7 7s.

Colour Chemistry and Dyeing Department.

Professor—A. G. Perkin, F.R.S., F.I.C.
Lecturer and Research Chemist—J. B. Oesch, Ph.D.
Lecturer in Dyeing and Research Assistant—P. E. King.
Demonstrator—A. E. Woodhead, M.Sc.

The Courses extend over periods of (*a*) three or (*b*) four years, and are intended for those who wish to obtain a full scientific and practical education in the art of dyeing, colour manufacture, &c. Diploma Course (*a*) is suitable for those who purpose to become dyeing chemists, and desire in the future to take part in the direction of the operations of dyeing and calico printing; *e.g.*, the sons of manufacturers, calico printers, managers, master dyers, &c. Honours Course (*b*) is more largely concerned with the study of colour manufacture, and is designed for the training of factory and research chemists required by works which are engaged in the preparation of dyestuffs.

Textile Industries Department.

Professor—Aldred F. Barker, M.Sc.
Lecturer in Textile Industries—H. Priestman.
Lecturer in Yarn Manufacture—T. Hollis.
Lecturer in Textile Chemistry—W. Harrison, M.Sc.
Engaged on Special Research—S. A. Shorter, D.Sc.
Assistant Lecturers—A. Yewdall, W. Law.

The courses of instruction extend over three or four years according to the Degree or Diploma Course selected. Shortened courses are arranged for special sections of the work. The practical equipment is designed to enable workers in the department to pass wool through every process from the Raw Material to the Finished Fabric. The Research Laboratories are equipped for the Scientific Investigation of the fundamental principles underlying all the processes involved in Wool Manufacture. Clothworkers' Scholarships are at the disposal of the University, and it is very probable that under the newly developed West Riding of Yorkshire Scheme valuable Travelling Scholarships will be available for Senior Textile Students.

Leather Industries Department.

Professor—H. R. Procter, D.Sc., F.I.C.
Assistant Lecturers and Demonstrators—W. R. Atkin, M.Sc.; F. C. Thompson, M.Sc.

The full Courses, which extend over a period of either two or three years, are suitable to all who intend to become Technical Chemists in the Leather Industry, or managers of important works, and are recommended to sons of tanners. The Courses include instruction in chemistry, a modern language, leather manufacture, and practical work in the Leather Industries Laboratory and Dye house. In 1914 the capacity of the University to undertake research in this branch of Applied Science was greatly extended by the establishment, in a new building adjoining the Leather Department, of the Procter International Research Laboratory, erected by the leather industries of the world in recognition of the work of Henry Richardson Procter, the first Professor of Leather Industries in the University.

Agricultural Department.

Professor—R. S. Seton, B.Sc.
Professor of Agricultural Chemistry—C. Crowther, M.A., Ph.D.
Assistant Lecturers in Agricultural Chemistry—W. Godden, B.Sc., A.R.C.S., F.I.C.; N. M. Comber, B.Sc., A.R.C.S.; J. A. Hanley, Ph.D.

The full Course occupies three years, and includes instruction in chemistry, physics, mathematics, geology,

botany, forestry, engineering and surveying, and the *principles of agriculture*, as well as *practical work in* the various laboratories and out door agriculture at the University Farm.

Institution for Research in Animal Nutrition.

Director—C. Crowther, M.A., Ph.D.

Biochemist—H. W. Dudley, M.Sc., Ph.D.

Research Assistant—H. E. Woodman, M.Sc., Ph.D.

The Institution is maintained by a special grant from the Board of Agricultute and Fisheries, and is closely associated with the Agricultural Department of the University.

Department of Coal-gas and Fuel Industries with Metallurgy.

Livesey Professor—J. W. Cobb, B.Sc., F.I.C.

Lecturer in Gas Chemistry—H. J. Hodsman, M.Sc.

The Courses extend over two, three or four years, and are suitable for those who are preparing for posts either as Gas Engineers or in Fuel and Metallurgical industries.

The Courses in Gas Engineering and the Technology of Fuel will chiefly deal with the manufacture and distribution of coal-gas and gas-lighting problems, by-product coking processes, and the production and application of gaseous fuels for heating and power purposes.

The Metallurgical Courses, besides dealing with general processes for the concentration and extraction of ores, will be chiefly directed to problems underlying blast furnace and open-hearth steel practice, and to the microstructure, physical properties, and heat treatment of steel and other industrial alloys.

Special attention is paid to the study of Refractory Materials.

Research Students are admitted to the University Laboratories on reduced terms.

Several valuable Fellowships and Scholarships are at the disposal of the University, including a Fellowship of £100 offered by the Institution of Gas Engineers, and the Salt, Akroyd, Brown, Baines, Emsley, Craven, and Clothworkers' Scholarships, and one of the 1851 Exhibition Scholarships. The Leeds City Council's and the North, East, and West Ridings County Council's Scholarships are tenable at the University of Leeds.

UNIVERSITY OF LIVERPOOL.

Professor of Inorganic Chemistry—E. C. C. Baly, C.B.E., M.Sc., F.R.S.

Professor of Physical Chemistry—W. C. McC. Lewis, M.A., Ph.D.

Professor of Bio-chemistry—W. Ramsden, M.A., D.M.

Professor of Organic Chemistry—R. Robinson, D.Sc.

Lecturer on Analytical Chemistry—J. Sineath Thomas, D.Sc.

Assistant Lecturers and Demonstrators—A. J. Allmand, D.Sc.; Francis W. Kay, M.Sc., Ph.D.

Lecture Assistant—H. H. Froysell.

The Session commences early in October.

The Classes meet the requirements of candidates for the Ordinary B.Sc. Degree, for Chemistry Honours, or for the M.Sc. or D.Sc. Degree in the University of Liverpool; for Degrees in Medicine of Liverpool; for the Pharmaceutical, Veterinary, Dental, and Public Health Diplomas; and for those studying Chemistry as a preparation for professional, technical, or commercial life. The Classes qualify for the Associateship of the Institute of Chemistry and other Examination Boards.

Lecture Courses.

A. General Introductory Course, including the principles of Organic and Physical Chemistry. Three Terms. Fee, £4.

Engineer's Course of Lectures with Practical Class. Two Terms. Fee, *including Practical class*, £6.

Course A.—General Elementary Chemistry, £4.

Course B.—Inorganic Chemistry. Fee, £3.

Course C.—Inorganic Chemistry (Honours Course). Fee, £4.

Course D.—Organic Chemistry. Fee, £3.

Course E.—Organic (Honours). Fee, £4.

Course F.—Physical Chemistry. Fee, £3.

Course G.—Honours Physical Chemistry. Fee, £4.

Course H.—Applied Inorganic Chemistry, £2 10s.

Course J.—Metallurgy. Fee, £2 10s.

Course K.—Applied Organic Chemistry. Fee, £2 10s.

Course L.—Electro-chemistry. Fee, £2 10s.

Also Pass and Honours Courses in Bio-chemistry.

Research students carrying out research work pay a fee of £3 per annum.

The Inorganic and Organic Chemical Laboratories provide accommodation for every kind of work and research in inorganic and organic chemistry and in metallurgy. There is also a laboratory devoted to spectroscopic work and research.

The Muspratt Laboratories of Physical Chemistry and Electro-chemistry adjoin the main chemistry buildings, and, owing to their full equipment, offer every opportunity for all manner of work and research in these subjects.

The Bio-chemical Laboratory is also separately housed, and provides facilities for work and research.

Students desirous of gaining a thorough theoretical and practical acquaintance with Technical Chemistry, or who intend to adopt Chemical work as a profession, must devote three or four years to special study, for which a full curriculum is provided. Fees:—

Per Week	One Term, Three Months.	Three Terms One Session
One day	£4	£7
Two days	5 10s.	10
Three days	7	13
Whole week	10 10s.	21

D.P.H. Course (see special syllabus).

Course for Dental Degree and Diploma (see special syllabus).

Technological Curriculum.

The curriculum extends over three or four years.

The Final Examination for the Associateship of the Institute of Chemistry may be taken after the third year. *Those students who have taken the Ordinary Degree of* B.Sc. may pass the M.Sc. Exam. in any subsequent year.

The Sheridan Muspratt Scholarship of £50 per annum, tenable for two years, will be competed for in December, 1918, on an Examination in subjects which are included in the first two and a half years of the above curriculum. Candidates should send in their names to the Registrar not later than November 15. The Campbell Brown and Sir John Willox Scholarships, on similar lines, are open for competition. Other Scholarships, Entrance Scholarships, and Free Studentships are also available to Students. Regulations as to these may be obtained from the Registrar.

ARMSTRONG COLLEGE, NEWCASTLE-ON-TYNE.

(IN THE UNIVERSITY OF DURHAM).

Professor of Chemistry—P. Phillips Bedson, M.A., D.Sc., F.I.C., F.C.S., J.P.

Lecturers in Chemistry—F. C. Garrett, D.Sc., F.C.S., and J. A. Smythe, D.Sc., Ph.D., F.C.S.

Assistant Lecturers and Demonstrators—A. Forster, M.Sc., Ph.D. (engaged on Munition Work), J. B. Firth, M.Sc., and Miss C. B. Schofield, M.Sc.

Lecturer in Agricultural Chemistry—S. Hoare Collins, M.Sc., F.I.C., F.C.S.

Assistant Lecturer in Agricultural Chemistry—A. A. Hall, M.Sc. Ph.D. (serving with H.M. Forces).

First Year Courses.—Division I.—*This* Course of Lectures will extend over the three terms of the Session, and is intended to serve as an introduction to the Science. The Lectures will be of an elementary character, and whilst framed to meet the requirements of First Year Students will also be serviceable to such as intend pursuing Chemistry in its various applications in the arts and manufactures, as, for instance, Brewing, Metallurgy, the Manufacture of Soda, Soap, Glass, &c. The subjects treated will include an exposition of the Principles of Chemistry, and a description of the preparation and

properties of the chief Elementary Substances, both metallic and non-metallic, and their more important native and artificial compounds. The class will meet on Mondays, Wednesdays, and Fridays, at 11 a.m., and will commence on Wednesday, October 3rd. Fee, £3 10s. for the Session.

Division II. Similar to Division I, but modified to meet requirements of Students for Degrees in Engineering and Mining. Mondays 12 to 1, Tuesdays and Thursdays 10 to 11. Fee, £3 10s. for Session.

Second and Third Year Courses.—These lectures are designed to form a part of the course of instruction in Chemistry, and to prepare students for the examinations in Chemistry for the degree of Bachelor of Science, Pass and Honours.

(*a*) Inorganic Chemistry.—Advanced Course. Tuesdays and Thursdays at 11 a.m. Fees, Lectures, £3 10s. per session, and £1 10s. per term.

(*b*) Organic Chemistry.—Aliphatic and Aromatic Compounds, Tuesdays and Thursdays at 10 a.m. Fees, Lectures, £3 10s. per session; £1 10s. per term.

(*c*) Organic Chemistry.—Advanced Course, Tuesdays and Thursdays at 12 noon for part of the session. Fees, Lectures, £3 10s per session; £1 10s. per term.

(*d*) *History of Chemistry and Chemical Philosophy.*—Saturdays at 10 a.m. Fees, Lectures, £3 10s. per session; £1 10s. per term.

(*e*) Physical Chemistry.—Tuesdays and Thursdays at 12 noon for part of the session. Fees, Lectures, £3 10s. per session; £1 10s. per term.

(*f*) Analytical Chemistry. — Fridays at 9.15 a.m. Fee, £1.

(*g*) The Rarer Elements and the Periodic Law.—Times to be arranged. Fees, Lectures, £3 10s. per session; £1 10s. per term.

Students taking Chemistry for Pass Degree will attend in their second year the course *a* and *f*, and in their third year the courses *b* and *d*, in addition to the necessary Laboratory practice.

Students taking Chemistry for Honours Degree will attend in their second year the courses *a*, *b*, and *f*, and in their third year the courses, *c*, *d*, *e*, and *g*, in addition to the necessary Laboratory practice.

A Lecture Course in Analytical Chemistry will be given on Fridays, at 9.15 a.m. Fee for the course, £1.

Metallurgy and Assaying.—Lecturer, Prof. Louis, M.A., D.Sc., F.I.C., F.G.S.; Demonstrator, H. Dean, M.Sc., A.R.C.M. A Metallurgical Laboratory is provided, in which instruction is given in the ordinary processes of Dry Assaying, and in the preparation and analysis of Alloys, &c. Fees as for Chemical Laboratory.

Agricultural Chemistry.—The instruction in this branch of Chemistry will consist of a series of Lectures and of special practical work in the Chemical Laboratory. Students will be expected to have a knowledge of Elementary Chemistry, such as may be obtained by attending the General Course.

The Lecture Course in Agricultural Chemistry is arranged for two days a week throughout the Session. Fee, £3 10s.

Practical Chemistry.—The Laboratory is open from 10 a.m. to 1 p.m., and from 2 to 5 p.m., except on Saturdays, when it closes at 1 p.m. *Laboratory Fees.*—Students working six days per week £5 10s. per term, £15 per session; one day per week, £2 per term, £5 per session.

Courses of Study.—Students will be divided into two classes:—(1) Regular, or Matriculated Students, who are also Members of the University of Durham; and (2) Non-Matriculated Students. Regular Students will be required to follow such a course of study in the subjects professed in the College as will enable them to pass the Examinations for the degree of Bachelor in Science of the University of Durham. Non-Matriculated Students will attend such classes as they may select. Every candidate for admission as a matriculated student must have passed the University Matriculation Examination.

Matriculation Examination.—In order to enter on a course of study for a Degree a student must have previously satisfied the Examiners in the following subjects:—(1) English, (2) English History, (3) Mathematics, (4) three of the following subjects, of which one must be a language:—(*a*) Religious Knowledge, (*b*) Latin, (*c*) Greek, (*d*) Ancient History, (*e*) French, (*f*) German, (*g*) some other language to be approved, (*h*) Experimental Science or Physics or Chemistry, (*i*) Botany or Zoology, (*j*) Mechanics, (*k*) Extra Mathematics, (*l*) Geography.

(i.). Candidates for degrees in Arts, who do not offer Latin in their Matriculation Examination or in the equivalent accepted as exempting therefrom, will be required to pass in Latin at a subsequent examination before entering upon the Arts course.

(ii.) Candidates for degrees in Commerce, who do not offer a Modern Foreign Language in their Matriculation Examination, or in the equivalent as exempting therefrom, will be required to pass in a Modern Foreign Language at a subsequent examination before entering upon the Commerce course.

(iii.). Candidates for degrees in Engineering (Civil, Mechanical, and Electrical) and in Naval Architecture will be required to take the following subjects from the list:—(1) English; (2) English History, including Geography; (3) one of the four languages—Latin, Greek, French, German; (4) Extra Mathematics; (5) and (6) either Experimental Science and Mechanics, or any two of the following subjects—Chemistry, Physics, Mechanics.

(iv.). Foreign Students may be exempted from the Matriculation Examination on report from the Board of Professors of Armstrong College, that they have received such an education in their own country as will enable them to profit by University study, and that they have sufficient knowledge of English to enable them to follow the courses of instruction they are entering for.

For detailed Syllabuses and complete Regulations the College Prospectus should be consulted.

Bachelorship in Science.—The degree of Bachelor of Science is conferred in Pass and Honours in Pure and Applied Science. For details of curricula, &c., the College Prospectus should be consulted.

Exhibitions.—Two Exhibitions of the value of £20 and £10 respectively will be awarded in September to Candidates desirous of attending the first year course of study in the College.

The examination will be held at the College, and will commence on Thursday, Sept. 26th, 1918. Candidates should send in their names to the Secretary on or before September 10th.

Several valuable Scholarships are available for students, including the Johnston Chemical Scholarship of the value of £60 for one year, which is open to Bachelors of Science of any British University; the examination for this Scholarship will be held during the week commencing October 7th. Candidates should send in their names to the Secretary on or before September 27th.

THE UNIVERSITY OF MANCHESTER.

Professor of Chemistry and Director of the Chemical Laboratories—Harold B. Dixon, C.B.E., M.A., M.Sc., Ph.D., F.R.S.

Professor of Organic Chemistry — Arthur Lapworth, D.Sc., F.R.S.

Reader in Biochemistry and Senior Lecturer in Chemistry—*C. Weizmann, Ph.D., D.Sc.

Senior Lecturers and Demonstrators—Norman Smith, D.Sc.; *E. C. Edgar, D.Sc.; F. P. Burt, D.Sc.; J. E. Myers, D.Sc.

Assistant Lecturers and Demonstrators—†W. J. Jones, M.Sc.; †J. R. Partington, M.Sc.; Colin Campbell, M.Sc.; H. Stephen, M.Sc.; W. K. Slater, M.Sc.; Leonora Pearson, M.Sc.

Professor of Metallurgy—C. A. Edwards, D.Sc.

Assistant Lecturer in Metallurgy—W. Whiteley, M.Sc.

Lecturers in Electro-Chemistry—†J. N. Pring, D.Sc.; E. Newbury, D Sc.

(* Under leave for special work for Ministry of Munitions. † Serving in H.M. Forces).

Chemistry Lecture Courses.

General Chemistry Course.—Tuesdays, Thursdays, and Saturdays, at 9.30, during the two Winter Terms.

This course is intended for Students commencing the study of chemistry.

Introduction to Organic Chemistry.—Mondays, Wednesdays, and Fridays, at 11.30, during the Summer Term. This course is designed to meet the requirements of Students preparing for the Intermediate B Sc. Examination.

Biochemistry, Theoretical and Practical—Tuesdays and Thursdays during the Summer Term. This Course prepares for Part III. of the first M B. Examination.

First Year Honours Course.—Mondays, Wednesdays, and Fridays, 11.30, during the two Winter Terms. The Non-Metals, and Introduction to Physical Chemistry.

Second Year Honours Course.—Mondays, Wednesdays, and Fridays, at 2, during the two Winter Terms. The Metals, and Introduction to Physical Chemistry.

Third Year Honours Course.—Theoretical and Physical Chemistry.

Organic Chemistry (General).—Mondays, Wednesdays, and Fridays, at 9 30, during the two Winter Terms.

Organic Chemistry (Advanced).—Tuesdays and Thursdays, at 9.30, during the two Winter Terms.

History of Chemistry—Short Courses during the two Winter Terms.

Chemistry of Colouring Matters—Theoretical and Practical Course during the Winter Terms.

Metallurgy—Introductory Course, followed by either—(A) Lead, Copper, Bismuth, Antimony, Zinc, and Tin; or (B) Iron and Steel Course A, two Lectures per week during the first half of the Session. Course B, one Lecture per week during the Session.

Electro-chemistry.—General Theoretical Course: One hour per week during the Michaelmas and Lent Terms. Applied Course: One hour per week during Michaelmas and Summer Terms.

B.Sc. with Honours in Chemistry.—The course extends over three years, and comprises systematic instruction by means of lectures and practical work in the laboratories.

The Research Laboratories for Inorganic, Organic, and Physical Chemistry, and for Metallurgy, are open to graduates and other advanced students.

For further particulars of any of these courses apply to the Registrar, Edward Fiddes, M.A., or to the Director of the Laboratories.

UNIVERSITY COLLEGE, NOTTINGHAM.

DEPARTMENTS OF CHEMISTRY AND METALLURGY.

Professor of Chemistry—F. Stanley Kipping, Ph.D., D.Sc., F.I.C., F.R.S.

Demonstrators of Chemistry—R. M. Caven, D Sc., F.I.C.; E. B. R. Prideaux, M.A., D.Sc.; and H. Lambourne, B.Sc. (on active service).

The Classes of the College are open to students of both sexes above sixteen years of age.

Lecture Courses.—The Chemistry Day Lectures extend over three years. In the first year a student attends a course on Inorganic Chemistry. In his second year he attends Lectures on both Inorganic and Organic Chemistry. In his third year he attends courses on Advanced Organic Chemistry, Physical Chemistry, and Advanced Inorganic Chemistry.

Demonstrations and Lectures on Analytical Chemistry are given, and Chemical Calculation and Tutorial classes are also held. Various short courses of lectures on special subjects are delivered during the Session.

Students may qualify themselves by attendance at these lectures and classes for the Examinations of the Universities of London, Cambridge, or Oxford, and for the Medical Examinations of the Royal College of Surgeons and of the Universities of Cambridge and Edinburgh: they may also obtain instruction in Chemistry for technical or other purposes, and can enter for a full Chemical Engineering Curriculum. Special attention is given to the requirements of candidates for the Associateship of the Institute of Chemistry.

Practical Chemistry and Metallurgy.—The Chemical and Metallurgical laboratories are open every day from 9 to 5, except on Saturday, when the hours are from 9 to 1; also on Tuesday and Thursday evenings from 7 to 9 Each Student works independently of other Students at a course recommended by the Professor. Instruction is given in general Chemical Manipulation, in Qualitative and Quantitative Analysis, and in the methods of Original Chemical Investigation and Research; Students are also enabled to work out the applications of Chemistry to Pharmacy, Metallurgy, Dyeing, Brewing, Iron and Steel, and other Manufacturing Processes.

Research Work.—Students or others wishing to undertake research work in pure or Applied Chemistry will be afforded every facility for doing so and may be admitted at reduced fees. The Laboratories are fully equipped with apparatus and chemicals necessary for such work.

Courses of Technical Chemistry Lectures are also given from time to time on Dyeing and Bleaching, Brewing, Plumbing, Gas Manufacture, and other processes of applied Chemistry.

Pharmaceutical Students are provided with Lectures and Laboratory work suitable for the preparation for the Minor and Major Examinations. Complete day and evening courses in Chemistry, Materia Medica, and Dispensing are also held for students preparing for the examinations of the Apothecaries' Hall.

The composition fee for full time in the Chemistry Department (lectures and laboratory) is £6 per term, and this fee covers all necessary apparatus and chemicals.

A composition fee of £6 per term is also charged for various complete courses, such as those required for the Institute of Chemistry, and for the degree examinations of London University.

Evening Classes.—Evening Lectures and Laboratory instruction will be given in Pure and Applied Chemistry, and the laboratories are open for practical work on Tuesday and Thursday evenings from 7 to 9. Fee for each Lecture Course, 5s.; for each Laboratory Course, 10s.

Full information concerning all College Classes is given in the College Prospectus, free from the Registrar.

THE UNIVERSITY OF SHEFFIELD.

Professor of Chemistry—W. P. Wynne, D.Sc., F.R.S.

Lecturer on Physical Chemistry—W. E. S. Turner, D.Sc., M.Sc.

Lecturers and Demonstrators—W. J. Jarrard, B.Sc.; J. Kenner, D.Sc., Ph.D.; C. R. Young, O.B.E., D.Sc., B.Sc.

Temporary Lecturers and Demonstrators—Emily G Turner, M.Sc.; Dorothy M. Bennett, M.Sc.; May Walsh M.Sc.

The Session will commence October 2nd.

Matriculation Course.—Tuesday and Friday at 9.30, Wednesday at 11.30 during Michaelmas and Lent terms. Fee, £2 12s. 6d., and three hours per week Laboratory work.

Candidates for the Intermediate Examination are required to satisfy the Examiners in three of the following subjects:—Pure Mathematics, Applied Mathematics, Physics, Chemistry, Zoology, and Botany. And those for the Final Examination in three of the following subjects:—Pure Mathematics, Applied Mathematics, Physics, Chemistry, Zoology, Botany, Physiology, Geology, Education, Geography.

Intermediate Course in Chemistry for B.Sc. or M.B., Ch.B. or B.Met.—Monday, Wednesday, Thursday, and Saturday at 9.30 a.m. £5 5s., and six hours per week Laboratory work during first year.

B Sc. Course in Chemistry.—Monday at 9.30 a.m. and Friday at 12.30 p.m. during second year, £3 3s.; Wednesday at 12.30 p.m., during two terms, Monday at 12.30 p.m. and Thursday at 11 30 a.m., during third year,

£3 3s.; and nine hours per week Laboratory work during second and third years.

B.Sc. with Honours.—Honours Students in Chemistry, after passing the Intermediate Examination, devote the whole of their time to the study of Chemistry, and are *expected to reach the standard for a pass in Chemistry for* the ordinary degree by the end of the second year. During the second or third year they devote one day a week to *lectures and practical work in a subsidiary subject*—Mathematics, Physics, or Metallurgy—selected for the degree. The third year is devoted to the advanced study of Chemistry, either chiefly Physical and Inorganic or chiefly Organic, as the student may select. At least four days a week during the second and third years are spent in the laboratory.

M.Sc.—This degree may be conferred upon a Bachelor *of Science with Honours who is of one year's standing* from the date of his graduation as a Bachelor of Science, or upon a Bachelor of Science who has either passed an examination in an Honours School subsequent to graduation, or has for at least one year after graduation done research work at the University, and has presented a thesis, approved by the Faculty of Pure Science, upon the research work done during that period.

Ph.D.—This degree may be conferred on registered graduates of the University of Sheffield, or of any other approved University, who have pursued a course of ad*vanced study and research in the University for a period* of not less than two academic years, have presented a thesis embodying the result of the research, and have been examined orally in matters relevant to the subject of the thesis.

D.Sc.—The degree of Doctor of Science may be conferred upon any Master of Science of not less than five year's standing from the date of his admission to the *degree of Bachelor, provided that he has published, in* recognised journals or transactions, a research or researches of special merit and approved by the Faculty of Pure Science as qualifying him for the degree.

Laboratory.—Working hours to be arranged between Professor and Students.

Sessional Fees for Day Students:—Three hours per week, £3 3s.; Six, £5 5s.; Nine, £7 7s.; Twelve, £9 9s.; Eighteen, £12 12s.; Twenty-four, £14 14s.; Thirty-two, £16 16s.; Honour or University Students taking eighteen hours or more per week, £12 12s.

Students joining the Laboratory for one term are charged one-half, and for two terms two-thirds of the Fees for the whole Session.

A course of Practical Chemistry which meets the requirements of candidates for the Diploma of Public Health is held during the Michaelmas and Lent terms. Fee, £6 6s.

An arrangement has been entered into with the Board of Education, London, S.W., which will enable Science Teachers to work in the Chemical Laboratory for three, six, or twelve hours a week on payment of one-quarter of the usual fee, the Board being willing to pay the remainder *under certain conditions, of which full informa*tion may be obtained on application to the Registrar of the University.

Evening Classes.—Lecture Class and Laboratory, on Thursday evening during the Michaelmas and Lent terms. Fee, £1 10s.

FACULTY OF METALLURGY.

Dean and Professor—J. O. Arnold, D.Met., F.R.S.

Senior Lecturers—F. K. Knowles, B.Met.; F. Ibbotson, B.Met., B.Sc., F.I.C.

Lecturer—J. H. Wreaks, B.Met.

Demonstrators—L. Aitchison, D.Met., B.Sc.; F. C. Thompson, D.Met., B.Sc.

Lecturer in Non-ferrous Metallurgy—G. B. Brook.

Demonstrator—F. Orme, M.Met.

Lecturer in Electro-metallurgy—W. R. Barclay, A.M.I.E.E.

This Faculty has been equipped to meet the require-ments of the local industries. The Laboratories are fitted with the most modern apparatus for metallurgical analysis, more especially with appliances for the rapid and accurate chemical examination of iron and steel, fuel, and refractory materials. It also contains a complete *pyrometric installation, and a laboratory for the study of* the micrographic analysis of metals fully equipped with specially designed microscopes by Ross, polishing *tables, etching appliances, incandescent light for* evening work, &c. The Faculty is now most complete for teaching the practical manufacture, the chemical constitution, and the physical properties of steel. Special attention is given to the determination of the microscopic constituents of steel. Although the chief industry of the district occupies the central position in the course of instruction, general metallurgy is dealt with in the Non-*ferrous Department described below. Students are thus* enabled to select and at once enter upon a course of scientific metallurgical training of immediate practical utility. They may take up and work through any portions of the course, but certificates are granted only to those who follow the prescribed courses and pass the necessary examinations. Lectures on Iron and Steel Manufacture, on Fuel and Refractory Materials, and Metallurgical Geology. Practical Metallurgy:—Laboratory, Furnaces, Foundry, and Testing Machine Course; Practical Course of Metallurgy other than Iron and Steel; Practical *Fuel Course for Students in Collieries or Gas Works.*

A steel works has been erected in connection with the Sheffield University at a cost of about £15,000, with a most varied and complete plant. The most recent addition to the steel works plant is a 3 cwt. Kjellin induction furnace worked by a 120 H.P. Motor-generator set with two-phase current. The Faculty of Metallurgy of Sheffield University is "in association" with the Royal School of Mines for teaching the advanced metallurgy of Iron and Steel.

There has been recently added to the curriculum Day and Evening courses in Electro-metallurgy and Non-ferrous Metallurgy. The Electro-metallurgical Laboratory is completely equipped for the practical study of every branch of the art of the Electro-deposition of metals, special attention having, however, been paid—in the selection and arrangement of plant and apparatus—to the specific requirements of the Sheffield trades. The plant and machinery is thoroughly up-to-date in character. *Working accommodation is provided for* 30 *students at* one time. The course extends over three university years.

The Non-ferrous Department has been established to meet the needs of the lighter Sheffield trades of Silver and Electro-plate, Brass, and allied industries. It is completely equipped for dealing with every phase of the work from the raw material. The melting shop is fitted with furnaces capable of dealing with casts up to 70 lbs. weight, so that commercial practice can be followed. Two large laboratories, the one with 32 places for preparatory *students, the other with accommodation for* 40 *advanced* students, provide the means for the Chemical examination of the alloys prepared. A Staff and Post graduate research laboratory completes the provision for the chemical side of the work. The Micrographic Laboratory is equipped with a complete Zeiss Photo-micrographic camera, direct driven polishing blocks, and Ross microscopes. The recalescence laboratory for the estimation of temperatures during melting, annealing, or other heat treatment has a complete pyrometric installation. An Arnold and Colver-Glauert Pyrometer permits of readings every 1° C. up to 1300° C. *Facilities are provided for* observing the thermal changes *in vacuo*. The Chronographic recorder is served by electric or coke furnaces, and the installation may be regarded as the most complete of its kind.

Degrees are awarded to successful students in Steel Metallurgy, and Associateships in both Steel and Non-ferrous Metallurgy.

UNIVERSITY COLLEGE, READING.

Professor of Chemistry—H. Bassett, D.Sc., Ph D. D. ès Sc., F.I.C.

Lecturer—J. W. Dodgson, B.Sc.

Assistant Lecturer—Miss Gladys Farnell, B.Sc.

Professor of Agricultural Chemistry—S. J. M. Auld, D.Sc., Ph.D , F.I.C.

Research Chemist in Dairying—J. Golding, F.I.C.

Lecturer in Agricultural Chemistry—J. A. Murray, B.Sc.

The lectures and laboratory work are so arranged as to be suitable for students preparing for the London B.Sc. (Pass or Honours), or for the College or other Diplomas in Agriculture, Horticulture, or Dairying. There is a general course of Intermediate standard, also another suitable for first year students of Agriculture and Horticulture. In their second and third years Science students attend special lectures in Inorganic, Organic, and Physical Chemistry, while Agricultural students take special courses under the Professor of Agricultural Chemistry. The laboratories are well equipped for all branches of practical work.

Halls of Residence—(Men) Wantage Hall, St. Patrick's Hall; (Women) St. Andrew's Hall, Wessex Hall, St. George's Hostel.

Full details of fees, scholarships, &c., can be obtained from the Registrar.

UNIVERSITY COLLEGE, DUNDEE.
UNIVERSITY OF ST. ANDREWS.

Professor of Chemistry—Alex. McKenzie, M.A., D.Sc., Ph.D., F.R.S., F.I.C.

Lecturer—J. K. Wood, D.Sc.

Demonstrator—(Vacant).

Lecture Assistant and Lab. Steward—J. Foggie.

The Session consists of three Terms:—The Martinmas Term begins early in October and ends before Christmas; the Candlemas Term begins early in January and ends about the middle of March; the Whitsunday Term begins in the middle of April and ends at the end of June.

Three Courses of Lectures are given, each extending through all three terms. The General Course, meeting four or five days a week (including Tutorial Meetings), is intended for beginners, and qualifies for Graduation Examinations in Arts (M.A. General), Science (First B.Sc.), and Medicine (First M.B., Ch B).

The Special and Honours Courses, each meeting twice or thrice weekly, qualify for Degree Examinations in Arts (Special and Honours, respectively), and in Science (Final B.Sc. on Intermediate and Higher Standard, respectively).

All three are General Courses, including Inorganic, Physical, and Organic Chemistry.

The Laboratories are well equipped, and instruction is provided for students in Arts, Science (Pure and Applied), Medicine (including Public Health); provision is also made for students desiring to undertake Research.

UNIVERSITY OF ABERDEEN.
CHEMISTRY.

Professor—Frederick Soddy, M.A., F.R.S.

Lecturer—Francis W. Gray, M.A., D.Sc.

I. *General Lecture Course, Systematic Chemistry.*—(Daily during the Winter Session at 3 p.m.). These lectures treat of:—(1) The Laws of Chemical Combination and the General Principles of Chemistry, including Chemical Calculations; (2) the Elements classified according to the Periodic Law; (3) Organic Chemistry; (4) Applications of Chemistry to the Arts and Manufactures. Two written Class Examinations are held. A Tutorial Class (without fee) is held in connection with the General Lecture Course. Fees, for first attendance, £4 4s.; for subsequent attendance, £3 3s.

II. *Elementary Practical Course for all Students.*—(Spring Term). Demonstration on Monday at 12 noon. For practical work the class will be divided into two groups; one group will meet on Tuesday and Thursday, and the other on Wednesday and Friday, from 10 a.m. to 1 p.m. This course is devoted to practice in Chemical Methods and in Elementary Qualitative Analysis. The instruction is under the direction of the Professor of Chemistry and the Staff. One practical examination is held at the end of the course, namely, the Degree Examination, but it must be attended by all, those not sitting the Degree Examination taking it as a Class Examination. Students in all faculties are required to pass this practical examination as well as the written examination, as part of the requirements for the Degree. The practical course should be taken, whenever possible, concurrently with the Systematic course. Fee, £3 3s. This fee includes the necessary apparatus and appliances, with certain exceptions such as platinum-foil and wire.

Scheme of Lecture Courses for the B.Sc. Degree in Chemistry (subsequent to Courses I. and II.).

III. Lecture courses in Organic, Inorganic, and Physical Chemistry are given by the Professor and Lecturers as the exigencies of the times allow. The following arrangement is given as liable to alteration:—

(*a*) Introductory Course of 30 lectures, mainly on some modern lines of advance in Physical Chemistry, by the Professor, three days weekly at noon in the Summer Session. Fee, £2 2s.

(*b*) A combined course of Physical and Inorganic Chemistry of about 80 lectures by Dr. Gray, two days weekly at noon in Summer Session, three days weekly in Winter Session, at noon in the First and at 3 p.m. in the Second Term. Fee, £3 3s.

(*c*) A course of 50 lectures in Organic Chemistry in Winter Session, three days weekly at noon in the First and two days weekly at 3 p.m. in the Second Term. Fee, £3 3s.

IV. *Chemical Laboratory.*—The Laboratory is open daily from 9 a.m. to 5 p.m. Each student on entering is allowed to arrange his hours of work so as to suit his own convenience, but must adhere to these hours when once fixed. The aim of the Laboratory Courses is to train the student in the practical methods of the science, so as to enable him to conduct chemical analysis and original research, and to apply chemistry to the arts and manufactures. Weekly Demonstrations, attendance on which is compulsory, are held in connection with the Laboratory Courses. (For further information as to fees and other conditions, see "University Fees").

Research.—The Laboratory is open for original work during both the Summer and Winter Sessions.

UNIVERSITY OF ABERDEEN AND ABERDEEN AND NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

Agricultural Chemistry and Forest Chemistry.

Professor—James Hendrick, B Sc., F.I.C.

Assistant—(Vacant).

I. A Preparatory Course in General Chemistry including Organic Chemistry is given for those who are unable to take the full University Course. The course in Inorganic Chemistry consists of about sixty Lectures with Practical Work (seven hours weekly) during the Winter Session. The course deals with the general principles of Chemistry, and with those parts of Inorganic Chemistry which are of more immediate concern to students of Agricultural Chemistry. The Practical Work goes along with and illustrates the Lectures. Fee, £4 4s.

The course in Organic Chemistry consists of about thirty Lectures, and about thirty hours practical work, and is given during the Summer Session. It deals especially with those parts of the subject which are directly related to Agricultural Chemistry. Fee, £2 2s.

II. *Agricultural Chemistry (General Course).*—This class meets daily during the Winter Session, and three times a week during the Summer Session, and includes both Lectures and Laboratory Work. The Lectures deal with the Chemistry of the Atmosphere, the Soil, Manures, Foods, Preservatives, Insecticides, &c. The Physiological Chemistry of Plants and Animals, the Composition and

Manurial Requirements of Crops, and Dairy Chemistry are also treated of. The Laboratory Work is primarily intended to accompany and illustrate the Lectures. Exercises dealing with the properties and composition of Soils, Manures, Feeding-stuffs and Waters, and with the impurities and adulterations of these, occupy much of the time given to Practical Work. The fee for the whole Course (Lectures and Practical Work) is £4 4s.

III. Forest Chemistry (General Course).—Students in Forestry take the greater part of the General Lecture *Course in Agricultural Chemistry, with special lectures on* the Chemistry of Timber and Forest Products. The early part of the Laboratory Work is the same as in the case of Agricultural Students, but the latter part is occupied with special exercises on Forest Products. Fee, £4 4s.

IV. *Laboratory*.—A Summer Course in Practical Chemistry is given to prepare students who have not previously done sufficient laboratory work for the course in Agricultural Chemistry or Forest Chemistry. Fee, £2 2s

V. The Laboratory is open daily from 9 a.m. to 5 p.m. *for students who wish to study the principles and practice* of Agricultural Chemistry or Forest Chemistry, or to undertake research in these subjects.

The fees mentioned above are subject to reduction in the case of students from counties and burghs within the College area, and there are a number of bursaries, some granted by local authorities and some by the University, open to students.

UNIVERSITY OF EDINBURGH.

DEPARTMENT OF CHEMISTRY.

Professor—James Walker, LL.D., D.Sc., Ph.D., F.R.S.

Lecturers—L. Dobbin, Ph.D.; A. C. Cumming, D.Sc.; J. E. Mackenzie, Ph.D.; S. A. Kay, D.Sc.; H. G. Rule, D.Sc., Ph.D.; A. M. Williams, M A., D Sc ; D. Ba'sillie, B.Sc., and Demonstrators.

The three working terms are each of ten weeks' duration, viz :—Autumn term, October to December; Spring term, January to March; Summer term, April to June.

Lecture Courses.—During the Winter Session a General Course of Chemistry for medical students is given. The class meets daily; fee, £4 4s. The First Course for Arts and Science students meets three times a week throughout the year; fee, £4 4s. The Second Course is given on Organic, Advanced Inorganic, and Physical Chemistry. The class meets three times a week throughout the year; fee, £4 4s. Tutorial Classes are held in connection with the First and Second Courses. All Arts and Science Classes are open to Women Students.

In addition to the above, Advanced Lecture Courses are given on particular branches of Physical, Organic, and Inorganic Chemistry.

Laboratories.—Practical classes for Medical Students meet *during the Winter Session and in the Summer Session*. (Fee, £3 3s.). The Elementary Laboratory course for Arts and Science students is held for four hours per week during the year. Fee, £4 4s. The advanced laboratories for Science and Arts Students engaged in analytical and advanced practical work are open daily from 9.30 till 4.30. Fees: Whole Day—Year, £16 16s.; one term, £6 6s. Half Day—Year, £8 8s.; one term £3 3s. Full Courses of instruction are given in Analytical, Practical Organic and Inorganic Chemistry (including Gas Analysis, Physico-chemical Measurements, and Assaying). *Facilities* are afforded to advanced students who desire to undertake chemical investigations.

Various prizes and scholarships are attached to the laboratory and general class.

Graduation.—Two Degrees in Pure Science are conferred, viz., Bachelor of Science (B.Sc.) and Doctor of Science (D.Sc.).

Candidates for Degrees in Science, if not graduates (by examination) in Arts in one of the Universities of the United Kingdom or in a Colonial or Foreign University recognised for the purpose by the University Court, must pass a preliminary examination in (1) English; (2) Latin, Greek, French, or German; (3) Mathematics; (4) One of the languages Latin, Greek, French, German, Italian, not already taken under (2), or Dynamics. In the case of a student whose native language is other than European the Senatus may, at the Preliminary Examination, accept such language as a substitute for a modern European language. The Senatus may also in such a case accept as an *alternative to Latin or Greek any other* classical language, such as Sanscrit or Arabic.

The First B.Sc. Examination embraces Mathematics, or Biology (*i.e.*, Zoology and Botany), Natural Philosophy, and Chemistry. The Final B.Sc. Examination in Pure Science includes any three or more of the following subjects:—Mathematics, Natural Philosophy, Astronomy, Chemistry, Human Anatomy (including Anthropology), Physiology, Geology (including Mineralogy), Zoology (including Comparative Anatomy), and Botany (including Vegetable Physiology). In the Final Examination two written papers are set in each subject professed, the second of a higher standard than the first. Candidates must pass the first *section in all, and the second section in at least one, of the* subjects professed; the same regulations apply also to the Practical and Oral Examinations. Chemistry in this examination embraces Inorganic Chemistry, Organic Chemistry, and Physical Chemistry. Practical Examination:—Complex Qualitative Analysis; Preparations; Gravimetric and Volumetric Analysis; Testing of Organic Substances. Each candidate taking the higher standard will also be examined on Ultimate Organic Analysis; Gas Analysis; and Physico-chemical Measurements.

A candidate for the D.Sc. Degree must submit a thesis on original work done by him. The Thesis must be approved before the candidate is allowed to proceed to Examination.

HERIOT-WATT COLLEGE, EDINBURGH.

Principal—A. P. Laurie, M.A., D.Sc., F.R.S E.

Staff.—A. Archibald Boon, F.I C., D.Sc., B.A. (Head of Department); Andrew King, M A, F.I.C.; J. Campbell Smith, B.Sc.; and Assistants.

The curriculum of this College comprises both Day and Evening Classes, each department providing the higher general and technical education.

There *is an extensive range of Chemistry Laboratories*, embodying the most modern developments in laboratory design and equipment, and including a complete plant for the production of liquid air. The Chemistry Courses are designed to meet the requirements of Analytical and Technical Chemists. The College is a recognised training centre for the examinations of the Institute of Chemistry, and students can obtain the necessary instruction in General Chemistry, and also the specialised instruction required for the Final Examination *for the Associateship of the Institute in the departments* of Organic Chemistry, Metallurgy, Foods and Drugs, and Bio chemistry.

The course for the Diploma of the College has been laid down on the same general lines as that required for the examinations of the Institute of Chemistry.

The Chemistry Courses are recognised by the University of Edinburgh as qualifying courses for the B Sc. degree.

Evening Classes are also provided in the subjects of Materia Medica and Botany.

There is also a Laboratory for the study of the Technical Mycology of Brewing, Distilling, Yeast Manufacture, Malting, Butter, Margarine, and Cheese Manufacture, Agriculture, Starch, Sugar, Preserve Making, &c. In this laboratory provision is made for the teaching of Biology, and the microscopic examination of Foods and Drugs, in connection with the examinations of the Institute of Chemistry.

Day Classes open on October 8th, and the Evening Classes on September 26th.

Matriculation Fee, 5s.; Composition Fees from £15 15s. to 21 guineas per annum. Full particulars are published in the Calendar of the College, issued early in September.

THE ROYAL TECHNICAL COLLEGE, GLASGOW.

Professor of Chemistry—G. G. Henderson, D.Sc., M.A., LL.D., F.R.S., F.I C.

Professor of Technical Chemistry—T. Gray, D.Sc., Ph.D., F.I.C.

Lecturer on Dyeing—A. B. Steven, B.Sc.

Lecturer on Sugar Manufacture—T. H. P. Heriot, F.C.S.

Professor of Metallurgy—C. H. Desch, D.Sc., Ph.D., F.I C.

Also, Professors and Lecturers in the other leading branches of Pure and Applied Science and Technology.

Session opens September 24th, 1918.

The main object of this College is to afford a suitable education to those who wish to qualify themselves for following an industrial profession or trade. It was founded by an Order in Council, dated November 26th, 1886, according to a scheme framed by the Commissioners appointed under the provisions of the Educational Endowments (Scotland) Act, whereby Anderson's College (established 1796), the Young Chair of Technical Chemistry in connection with Anderson's College, the College of Science and Arts, Allan Glen's Institution, and the Atkinson Institution were placed under the management of one governing body.

The Diploma of the College is awarded to Day Students who have attended prescribed courses of instruction and passed the necessary examinations. The ordinary courses extend over three years, but arrangements are made for advanced students continuing their studies in special departments. The diploma course in Chemistry extends over four years.

Students who have matriculated at the University of Glasgow can qualify for the degree of B.Sc. in Applied Science by attendance on the Day Classes of the College.

Complete courses of instruction are provided in both Day and Evening Classes.

Copies of the Calendar for 1918-1919 may be had from the Director, Mr. H. F. Stockdale,; price by post, 1s 4d. Prospectuses will be sent free.

UNIVERSITY OF ST. ANDREWS.

UNITED COLLEGE OF ST. SALVATOR AND ST. LEONARD

Professor of Chemistry—James C. Irvine, Ph.D., D.Sc., F.R.S.

Reader in Organic Chemistry — W. N. Haworth, D.Sc., Ph.D.

Assistants—Geo. Robertson, M.A.; B Sc.; E. S. Steele. M.A., B.Sc.; Grace C. Leitch, M.A., B Sc.; Helen Gilchrist, B Sc.

The Session begins on October 8th. A Competitive Examination, open to intending Students of Arts, Science, and Medicine, for about thirty-six Bursaries, ranging in value from £50 to £10 each per annum, is held annually in June. (For 1919 entries are due May 20th) One of these is open to Men or Women, and fifteen are restricted to Women, nine of the latter being intended for women who at the conclusion of their Arts or Science Course will proceed to Medicine. The remainder are open to men only.

A Hall of Residence is provided for Women Students.

Two Degrees in Science are conferred by the University of St. Andrews, viz., Bachelor of Science (B.Sc.) and Doctor of Science (D.Sc.), and Chemistry is also included in the curriculum for the M.A. Degree, and the M.B., Ch B. Degrees.; the regulations will be found in the "University Calendar."

Lecture Courses.

Three distinct Courses of Lectures are given, each extending over the three terms of the academic year.

First Year's Course.—This Class meets at 11 o'clock on five days in the week. The introductory lectures treat of the Nature of Chemical Action, the Classification of Substances into Elements and Compounds, the Phenomena of Oxidation, and the Composition of Air and Water. The Laws of Chemical Combination and the Atomic Theory are next discussed, after which the more commonly occurring elements and inorganic compounds are described systematically. Elementary Organic Chemistry is also included in the Course.

Special attention is given to those parts of the science which are of general educational value, and as much of the theory of chemistry is introduced as is compatible with elementary treatment.

This course of instruction is intended to meet the requirements of the M.A., First Science, and M.B., Ch.B. Exams., so far as Theoretical Chemistry is concerned.

Second Year's Course.—The first part of the Course is devoted to Organic Chemistry, and the second part to General and Physical Chemistry, the instruction in general being such as is required for the Final Science Exam. on the Lower Standard and the Special Exam. for the M.A. Degree.

Third Year's Course.—Short courses of lectures on selected topics are given to Students preparing for the B.Sc. on the Higher Standard or the M.A. Degree with Honours.

Certificates are awarded on the results of examinations, and the "Forrester Prize" of about £10 is awarded to the best Student of the year.

Fee for the Session, for each Course, £4 4s.

Practical Chemistry.

The Laboratory is open daily from 9 a.m. to 4 p.m., except on Saturdays, when it is closed at 1 p.m. The work pursued in the Laboratory comprises:—(1) The performance of experiments illustrative of the Principles of Inorganic and Organic Chemistry; (2) Qualitative and Quantitative Analysis; (3) Practical Physical Chemistry. Each student pursues an independent course of study under the supervision of the Professor or Demonstrator, the nature of the work varying with the proficiency of the student and the particular object he may have in view. Suitable courses of instruction in Practical Chemistry are provided for candidates for the Exams. in Arts, Science, and Medicine.

The fee for the Ordinary Course of Practical Chemistry is £3 3s. and for the Advanced Course £10 10s.

Original Research.

A special Research Department has been instituted by the University, the laboratories of which are open to students who give proof of their capacity to conduct original investigation. Graduates of other Universities who spend two years in the laboratory as Research Students are eligible for the D.Sc. degree of the University, and special chemicals and apparatus are provided free of charge. Graduate workers can also qualify for the Berry, 1851 Exhibition, and Carnegie Research Scholarships or Fellowships.

Students may work either independently or in collaboration with the Professor, to whom all communications should be addressed.

QUEEN'S UNIVERSITY, BELFAST.

Lecturer in Inorganic Chemistry—R. Wright, D.Sc., &c.

Lecturer in Organic Chemistry (acting as Professor of Chemistry)—A. Killen Macbeth, M A., D.Sc., F.I.C, &c.

I.—*Chemistry.*—The lectures are delivered at 12 o'clock on the first five days of each week, and terminate about the end of March. The course embraces the elements of Physical, Inorganic, and Organic Chemistry. Fee, £3 3s.

II.—*Advanced Chemistry.*—Inorganic and Organic. The lectures are given at such days and hours as suit the convenience of the class. Fee, £3 3s.

III.—*Practical Chemistry.*—In this course the Students are instructed in the general methods of Qualitative and Quantitative Analysis, Inorganic preparations. &c. The class is held on four days in the week during the second term for two hours each day. Fee, £4 4s.

IV.—*Practical Chemistry for Engineering Students.*—A special course is given during the first term. Fee, £3 3s.

V.—*Laboratory Pupils.*—The Chemical Laboratories are open from the second week in October to the beginning of July, on the first five days of the week, from 10 a.m. —5 p.m. (except during the vacations). Students are admitted as working pupils on payment of a fee of £3 3s. per term. *Facilities are provided for Students who wish to undertake research work.*

Scholarships.—The following College Scholarships are awarded specially in connection with the schools of Chemistry and Physics:—Post Graduate Scholarships in Chemistry alone awarded annually of £50, and tenable for one year. Andrews Studentship in Chemistry and Physics, value about £73 annually, and tenable for two years. 1851 Exhibition Scholarships: One of these Scholarships has hitherto been placed at the disposal of the College every two years, of the annual value of £150, tenable for two or under special conditions for three years, and also one of the Industrial Bursaries.

UNIVERSITY COLLEGE, CORK.

A Constituent College of the National University of Ireland.

Professor—Augustus Edward Dixon, M.D.
Assistant Lecturer—John Taylor, M.Sc.
Demonstrators—R. T. J. Kennedy, B Sc.; T. A. Conroy, M.A.

The College Session will commence in October, 1918, and end in June, 1919. All classes are open to male and to female students.

The following courses are provided:—

1. First Year Course for B.Sc.—*General and Elementary* Physical Chemistry, Inorganic Chemistry, Introductory Organic Chemistry, Practical Chemistry.
2. Second Year Course for B.Sc.—Advanced Inorganic Chemistry, Advanced Organic Chemistry, Practical Chemistry.
3. Third Year Course for B.Sc.—Physical Chemistry, Advanced Organic Chemistry, Practical Chemistry.
4. Courses in Systematic and in Practical Chemistry for students of Medicine proceeding to the Degrees of the University, or to the Examinations of the Medical Licensing Bodies of Dublin and of Edinburgh.
5. Courses in Systematic and in Practical Chemistry for Students of Engineering.
6. Laboratory Practical Course for the Diploma in Public Health.

Full particulars as to Lectures, Fees, Scholarships, Exhibitions, &c., are contained in the Regulations extracted from the College Calendar, which will be supplied *on application to the Registrar.*

NATIONAL UNIVERSITY OF IRELAND.

University College, Galway.

Professor—(Vacant).
Demonstrators—Miss R. Clarke, B.A., D.Sc., F.I.C., and P. H. Gallagher, M.Sc.

The Session commences in October and ends in June.

Faculty of Science.—1. *First Year's Courses.*—Laboratory: Inorganic preparations, simple quantitative and simple qualitative determinations. Lectures: A study of the chief non-metallic elements, their reactions and compounds, the molecular and atomic hypotheses, the leading metals, and an elementary consideration of the constitution and reactions of typical isomathic and cyclic compounds. 2. *Second Year's Courses.*—Laboratory: Organic preparations, complex qualitative and quantitative inorganic determinations. Lectures: Advanced inorganic and organic chemistry. 3. *Third Year's Courses.*—Laboratory: Qualitative and quantitative organic determinations, molecular weight determinations, gas analysis, thermo-electro and photo-chemical and other physical determinations. Lectures: General, physical, inorganic, and organic chemistry, a detailed study of special branches, and the historical development of chemistry.

Faculty of Arts.—First Year's Course.—Same as Faculty of Science.

Faculty of Medicine.—First Year's Courses.—Laboratory: Same as in Faculty of Science, but less detailed, and including the detection of the chief alkaloids, glucosides, and carbohydrates. Lectures: Same as in Faculty of Science, first year.

Faculty of Engineering.—First Year's Courses.—Laboratory: Same as in Faculty of Science, but less detailed, and including a special study of metals, alloys, and other materials used in building construction, also determination of hardness in waters. Lectures: Same as in the Faculty of Science, but not including organic chemistry.

Chemistry is one of the subjects required for numerous Scholarships in the Faculties of Science, Medicine, and Engineering. The Royal Commissioners for the Exhibition of 1851 offer every two years a Science Research Scholarship of £150 per annum. This Scholarship has already been held by six Chemistry Students of this College.

For details as to Fees, Regulations as to Scholarships, and other particulars apply to O'Gorman and Co., Galway.

ROYAL COLLEGE OF SCIENCE, DUBLIN.

The Royal College of Science supplies, as far as practicable, a complete course of instruction in Science applicable to the Industrial Arts, and is intended also to aid in the instruction of teachers for the Schools of Science.

Diplomas are awarded in the Faculties of Engineering (Mechanical and Electrical), Applied Chemistry, and Agriculture. If accompanied by a certificate from the Professor of Chemistry, the Diploma of Associate of the Royal College of Science in the Faculty of Applied Chemistry is recognised by the Council of the Institute of Chemistry of Great Britain and Ireland as qualifying candidates for admission to the final practical examinations of the *Institute.*

The instruction in Chemical Science includes (1) General Inorganic Chemistry, Elementary and Advanced; (2) Organic Chemistry, Elementary and Advanced; (3) Analytical and Experimental Chemistry; (4) Physical Chemistry; (5) Metallurgical and Technological Chemistry and Assaying; (6) Instruction in Chemical Research.

Fees payable by Non-Associate Students:—£2 for each separate Course of Lectures. For Analytical Chemistry and Research—£5 for three months; £9 for six months; £12 for the entire session. Assaying—£5 for three months; £9 for six months. £12 for the entire session.

There are six Royal Scholarships of the value of £50 each yearly, with Free Education, including Laboratory Instruction, tenable for three years; two become vacant each year; they are awarded on the results of their examinations to Associate Students, not being Royal Exhibitioners, who have been a year in the College.

*A limited number of Entrance Scholarships and Teacher*ships-in-Training in Science and Technology are competed for each year. These Scholarships are of the value of £50 a year for four years, and, in addition, entitle the holder to free instruction during the full Associateship Course.

For further particulars apply to the Registrar.

PROFESSIONAL CHEMICAL QUALIFICATION

(F.I.C. and A.I.C.).

The Institute of Chemistry of Great Britain and Ireland.—The Institute of Chemistry was founded in October, 1877, and incorporated by Royal Charter in June, 1885, to maintain the efficiency and integrity of the profession of Chemistry, including professional consulting and technological chemists, public analysts, and chemical advisers.

The Studentship.—Every Candidate for registration as a Student is required to produce evidence that he is *at least seventeen years of age, and that he has passed an*

approved Preliminary Examination or otherwise satisfied the Council as to the standard of his general education. He must also show that, at the time of making application for registration, he is working at a College or University recognised by the Council, or under the direction of a Fellow of the Institute in an approved laboratory or works.

The Associateship.—Candidates for the Associateship are required to produce evidence of having passed an approved preliminary examination and of having undergone four years systematic training, or the equivalent, in chemistry, physics, and allied sciences. Admission by *examination is granted* to candidates who have been trained, in accordance with the regulations, in a recognised University or College, or partly in such Institution and under Fellows of the Institute in laboratories or works. The Council will also consider specially and on their merits the cases of candidates who have been engaged in the study and practice of chemistry for at least ten years.

The Examination comprises, in addition to a general knowledge of all branches of chemistry, a thorough knowledge of one branch—Mineral chemistry; metallurgical chemistry; physical chemistry; organic chemistry; chemistry (including microscopy) of food and drugs, fertilisers and feeding-stuffs, soils, and water; biological chemistry; or chemical technology. Candidates are required to translate foreign technological literature, with the aid of dictionaries. Candidates taking the food and drugs section must take a course in botany, and those taking biological chemistry a course in biology.

Admission to the Associateship without examination *may be granted to candidates who have obtained certain* University degrees with first or second class honours in chemistry, or other specially recognised diplomas; and in exceptional cases to candidates who have otherwise complied with the conditions of the Charter with regard to age, general education, scientific training, experience, &c.

The Fellowship.—Admission to the Fellowship is open to Associates of three years standing by examination or by satisfying the Council that they have carried out original research, or have devised processes or inventions, or that they are possessed of knowledge and ability of sufficiently high order to warrant their exemption from further examination. In special cases candidates other than Associates, who have been *systematically trained and have* had considerable experience, may be examined for the Fellowship without passing through the grade of Associateship. In exceptional circumstances candidates who have been systematically trained and have had considerable experience, and have obtained positions of responsibility, may be elected to the Fellowship without examination.

Full particulars are given in "The Book of Regulations for the Admission of Students, Associates, and Fellows," which may be obtained (gratis) from the Registrar, 30, Russell Square, London, W.C. 1. Past Examination Papers, Annual Sets, 6d. each.

CHEMICAL LECTURES, CLASSES, AND LABORATORY INSTRUCTION.

City and Guilds of London Institute—The Institute was founded in 1878, incorporated under the Companies Acts in 1880, *and received the grant of a Royal* Charter by Her late Majesty Queen Victoria in 1900. It is an association of the Corporation and Livery Companies of the City of London, instituted "for the purposes of all such branches of Science and the Fine Arts as benefit or are of use to, or may benefit or be of use to, productive and technical industries especially, and to commerce and industry generally or any branch thereof, and for the utilisation of such means as will promote the several exclusive purposes aforesaid." The operations of the Institute are divided broadly into four branches:—(1) The City and Guilds (Engineering) College, (2) the City and Guilds Technical College, Finsbury, (3) the City and Guilds South London Technical Art School, and (4) the Department of Technology of the Institute. *The City and Guilds (Engineering) College, Exhibition Road, S.W.* forms the Engineering Section of the Imperial College of Science and Technology, and is conducted by a Delegacy representing the Imperial College, the City and Guilds of London Institute, and the Goldsmiths' Company. The College was included as a School of the University of London in the Faculty of Engineering in 1898. The courses of instruction cover a period of three years, and are in Civil and Mechanical Engineering, and in Electrical Engineering. They commence once a year in October, after the Matriculation or Entrance Examination of the College, and necessitate attendance through the Session. The age of admission is over 16 years. The fee for matriculated students attending a diploma course is £38 a session, if paid in advance. *The City and Guilds Technical College, Finsbury*, provides courses of instruction in Civil, Mechanical, and *Electrical Engineering, and* Applied Chemistry. The courses of instruction and the practical work in the laboratories and workshops are arranged solely with the object of providing a training on broad, practical, and scientific principles, in those matters which experience has shown best to fit a student to enter some one of the many careers connected with Civil, Mechanical, Electrical, or Chemical Industries or professions. The age of admission is 15 years. There is an entrance examination once a year, in September, and the fee for the Session is £20 if paid in advance. The object of the Institute's *Department of Technology, Exhibition Road*, S.W., is the registration and inspection of classes *in all branches of Technology, Domestic Subjects, and in* Manual Training, and the holding of annual examinations in the subjects taught in such classes throughout the country and in the Colonies. The Programme of the Department, including regulations for registration and inspection, and for the award of Teachers' Certificates in Manual Training and Domestic Subjects, with Syllabus of Subjects, &c., published by Mr. John Murray, Albemarle Street, London, and is obtainable through any bookseller.

City of London College, White Street, Moorfields.—A. W. Bain, B.A., B.Sc., F.I.C., and Assistants. Classes and Laboratory Practice in Chemistry, open to Students of both sexes. Courses on Commercial Product.—Milling (Flour), Tea, Textiles. *Session commences Sept. 30.*

Battersea Polytechnic.—Principal, F. H. Newman, M.A., Ph.D. Inorganic, Organic, and Technological Chemistry, John Wilson, M.Sc. (Vict.), F.I.C. (Head of Chemical Department), and Assistants. Complete three or four years' day diploma courses of Instruction are given in Chemistry (Inorganic and Organic), together with Physics, Mathematics, and Engineering subjects, &c., for intending technological and works chemists. Certain of the Courses (Day and Evening) are recognised by the University of London in preparation for the B.Sc., for which examinations (Pass and Honours) complete courses of *instruction, under recognised teachers, are provided.* Special Evening Courses (theoretical and practical) in various Technical subjects, as Coal-tar Colours, Applied Bacteriology, Food and Drug Analysis, Pharmacy and Dispensing, Materia Medica, Paper Testing, Oils and Fats, and Gas Analysis. Special day and evening courses for the examination of the Institute of Chemistry, the Pharmaceutical Society, the Apothecaries' Hall, and the Conjoint Medical Board. For further information see the Polytechnic Calendar, an abridged copy of which may be obtained gratis from the Secretary of the Polytechnic.

Borough Polytechnic Institute, Borough Road, S.E.—Chemistry Department under the direction of C. Dorée, M.A., D.Sc. Evening Lectures and Laboratory Work in Inorganic and Organic Chemistry. Special Lectures and Laboratory Courses in Electro-chemical Analysis, and the Chemistry and Technology of the Essential Oils. Special Courses of Lectures on various Technical subjects. (For further information see Institute Syllabus).

BIRKBECK COLLEGE, Breams Buildings, Chancery Lane. — Chemistry Courses conducted by G. Senter, D.Sc., Ph.D. (assisted by F. Barrow, M Sc., Ellen Field, MSc., and Mabel G. Barrett, B.Sc.), prepare for various Examinations, the B.Sc. and M.B. Degrees of the London University, Conjoint Board, Pharmaceutical Examinations, Board of Education, &c. The Session will commence on Monday, Sept. 24. The Day and Evening courses of study include Chemistry, Physics, Botany, Zoology, Geology, Mathematics, Latin, Greek, Modern Languages, Economics, Geography, Logic, History, and various branches of Law. All the Courses are conducted by recognised teachers of the University and provide for the Examinations of the University of London. The Calendar supplies detailed information respecting the Courses of Study, Examinations, &c.

NORTHERN POLYTECHNIC INSTITUTE, Holloway, London, N.—Principal, R. S. Clay, D.Sc. Instruction in theoretical and practical Inorganic and Organic Chemistry. Systematic Day and Evening Courses for the London University Degrees, Pass and Honours, also for the Board of Education examinations. Prospectus sent free on application to the Secretary.

NORTHAMPTON POLYTECHNIC INSTITUTE, St. John Street, E.C. 1.—Principal, R Mullineux Walmsley, D.Sc., &c. Day Courses in Electro-chemistry and Engineering Chemistry, and evening classes in Electro chemistry, Electro-plating, Engineering Chemistry, Electro metallurgy, Electrotyping, Stereotyping, and Metal Colouring. (For full details see Prospectus). Telephone, Holborn 1104.

SOUTH WESTERN POLYTECHNIC INSTITUTE Manresa Road, Chelsea. — This Institute offers facilities for academic and technical education in many branches of Chemistry and Metallurgy. The department has designed both day and evening courses to meet the many requirements of these professions in London. Complete courses in General Chemistry, Metallurgy, and Assaying requisite for the B.Sc. and A.I.C. Exam nations. Ample opportunity for individual work has been arranged for both day and evening students. A full list of these courses will be supplied on application. A feature of the laboratory work is the facility given for specialising in any particular branch of the above subjects, thus supplying a much needed want to men who have neither the time nor necessity for attending a degree course. The various lecturers will be pleased to advise intending students with regard to selection of courses. The department is under the control of J. B. Coleman, A.R.C.S., F.I.C., F.C.S., and the aim of the Institute is to make its courses of sound practical use to those engaged in Chemical Industries. Further particulars respecting the courses can be obtained from the Secretary (Room 79).

EAST LONDON COLLEGE, Mile End Road.—Chemistry: Professor, J. T. Hewitt, M.A., D.Sc., Ph.D., F.R.S.

SIR JOHN CASS TECHNICAL INSTITUTE, Jewry Street, Aldgate.—Principal, Charles A. Keane, D.Sc., Ph.D., &c., assisted by F. J Harlow, A.R.C.S., B.Sc., H. J. S. Sand, D.Sc., Ph.D., H. V. A. Briscoe D.Sc., A.R.C.S., &c., Arthur R. Ling, F.I.C., C. O. Bannister, A.R.S.M., M.I.M.M., G. Patchin A.R.S.M., Arthur Harden, D.Sc., F.R.S., &c., J. S. S. Brame, E. C. Snow, M.A., D.Sc., E. H. Boote. The new Session of the Sir John Cass Technical Institute, which is especially devoted to technical training in Experimental Science and in the Artistic Crafts, will commence on Monday, Sept 23. The instruction in experimental Science provides systematic courses in Mathematics, Physics, and Chemistry for London University examinations in addition to the courses on higher technological instruction and on inorganic, organic, physical, and analytical chemistry, which form a special feature of the work of the Institute. The curriculum in connection with the Fermentation Industries includes courses of instruction on Brewing and Malting, and on the Microbiology of the Fermentation Industries. In the department of Physics and Mathematics, a special course of Lectures will be given on the Theory and Application of Mathematical Statistics, the latter of which will treat of the application of modern mathematical methods of dealing with statistical data in social, educational, economic, and physical problems. Opportunity will be given to students to investigate problems on their own account. Special preparatory courses are provided in this department in Mathematics and Physics for those wishing to qualify for industrial positions for which a knowledge of these subjects is essential. In the Metallurgy department, in addition to the ordinary courses, special advanced courses are provided on Gold, Silver, and allied metals, on Iron and Steel, on Metallography and Pyrometry, on Heat Treatment of Iron and Steel, and on the Mechanical Testing of Metals and Alloys. Full facilities are provided for advanced practical work and research in Chemistry, Metallurgy, and Physics.

EAST HAM TECHNICAL COLLEGE.—Principal, W. H. Barker, B Sc. *Head of Chemical Department*—A. E. Dunstan D Sc. (Lond.). Lecturers—F. B. Thole, D.Sc; E. D. Griffiths, B.Sc.; R. W. Wilson, F.C.S Demonstrators—S. J. Plaice; A. G. Mussell. Chemical Engineering and Gas Engineering—A J. Nice. Gas Supply—G. Jenkins. Soap Manufacture and Oils, Fats, and Waxes—C. J. Benedict. Tar Distillation, &c.—A J Nice and A. E. Dunstan, D Sc. Metallurgy—F. B. Thole, D.Sc. Sugar Manufacture—A. Wade. Painters' Oils, Colours, and Varnishes—R. A. Phillips. Evening Classes and Secondary School.

BLACKBURN MUNICIPAL TECHNICAL SCHOOL —Chemistry: Robert H. Pickard, D Sc. (Lond.), F.R.S., assisted by F. J. Cooper and Miss E. Holt, B.Sc. Session commences Sept. 24. Full details of the Classes are given in the "Students' Handbook," which may be had at the Institution (price 1d., by post 3d).

REDRUTH SCHOOL OF MINES (now incorporated in the School of Metalliferous Mining, Cornwall).—Complete courses of Practical and Theoretical instruction are given in Inorganic Chemistry, Assaying, Mineralogy, Blowpipe Analysis, Mine Surveying, Geology, Principles of Mining, Ore Dressing, Mechanical Engineering &c., for intending Assayers, Mineral Chemists, Mining Engineers, and Surveyors. Practical instruction in Mining given at the School Mine. Syllabus on application to the Principal, T. Knowles, B.A., B.Sc., Camborne.

MANCHESTER COLLEGE OF TECHNOLOGY (University of Manchester.—The work of the College includes advanced study and research in various branches of science and technology, and undergraduate courses in the Faculty of Technology, extending over three years and leading to Degrees and Certificates in Mechanical Engineering, Electrical Engineering, Sanitary Engineering, Textile Industries, Printing and Photographic Technology, Architecture, and in the following branches of Applied Chemistry:—General Chemical Technology, Chemistry of Textiles (Bleaching, Dyeing, Printing, and Finishing), Paper Manufacture, Metallurgy and Assaying, Fuels, Chemical Technology of Brewing, Electro-chemistry, Photography. The provision for the teaching of Chemistry is of an exceptionally complete character. In addition to the laboratories for Inorganic and Organic Chemistry, Metallurgy, Brewing, Bleaching, Dyestuffs Manufacture, Dyeing, and Electro-chemistry, an extensive equipment (including machinery and appliances on an industrial scale) for demonstration, experiment, and original research in connection with the Bleaching, Dyeing, Printing, and Finishing, and Paper-making industries is provided in a separate building. A Brewhouse is also equipped on the low gravity principle with a plant of four bushel capacity.

TECHNICAL COLLEGE, SWANSEA.—Principal, W. M. Varley, M.A., D.Sc., Ph D. Chemistry, E. A. Tyler, M.A.; Metallurgy. H. I. Coe, M.Sc.; Physics, J. C. Kirkman, B.Sc. Day and Evening Courses in Pure and

Applied Chemistry, Chemical Engineering. Metallurgy, and for Pharmaceutical, Medical, and Dental Students. Session opens Sept. 20th.

Wolverhampton Municipal Science and Technical School.—Principal, J. D. Coales, D.Sc., M.I.E.E.; Inorganic and Organic Chemistry, Th. J. Murray, M.Sc., Ph.D., and W. J. Lewis, B.Sc.; Physics, A. T. Harrison, B.Sc.; Botany, Mrs. Ashdown-Clarke, B.Sc. Human Physiology and Hygiene, H. J. Tench. Materia Medica and Pharmacy, F. W. Thompson, Ph.C. Day Classes in Chemistry, and Evening Classes in Chemistry, Physics, Botany, French, &c. Special arrangements are made for the requirements of Pharmaceutical and Medical Students and Chemical Trades. Session commences Sept. 9th. For other particulars and programme, apply G. F. Chell, Secretary.

Municipal Technical Institute, Belfast.—Principal, F. C. Forth, F.R.C.Sc.I. Chemistry, Prof. H. Wren, M.A., Ph D., D.Sc. Day and Evening Courses.

NOTICES OF BOOKS.

Edible Oils and Fats. By C. Ainsworth Mitchell, B.A., F.I.C. London, New York, Bombay, Calcutta, and Madras: Longmans, Green, and Co. 1918. Pp. xii+159. Price 6s. 6d. net.

The chemistry of the fatty substances which are suitable for use as human food is fully discussed in this book, which will be found a very useful general handbook on the subject. The balance between theory and practice is well maintained, and the nature and composition of fats are treated in sufficient detail for most of the purposes of the specialist. Recent work is given a good deal of prominence, especially in the more practical parts in which modern methods are fully described. Thus the question of the causes of rancidity and its estimation is well treated, and modern processes for extracting and purifying fats and oils are discussed. Again, in the chapter on methods of examination quite recent work is described. Two chapters deal with the characteristics and ways of distinguishing the individual edible oils and fats, and butter and butter-fat are treated in considerable detail. The hardening of fats by hydrogenation and the preparation of margarine are described in outline, and many references are given to modern literature on the subject.

Sir William Ramsay, K.C.B., F.R.S. By Sir William A. Tilden, F.R.S. London: Macmillan and Co., Ltd. 1918. Pp. xvi+311. Price 10s. net.

The history of the discovery of the inert gases of the atmosphere is a chapter in science which invariably makes a strong appeal to the young student, and every boy who learns inorganic chemistry should be acquainted with it. The dramatic way in which the discoveries were made, and the methods by which fresh knowledge is acquired of materials which were supposed to have been thoroughly investigated, can be made the basis of most enlightening and truly educational lessons in science, and teachers can have no better account of the work of Sir William Ramsay than is to be found in this book. Students also cannot fail to get entertainment as well as instruction from it. A very sympathetic account is given of a man of charming personality, who was a great man as well as a great discoverer. Sir William Ramsay's energy, enthusiasm, gaiety, and wide interests all combined to make his life an exceptionally full one, and the extracts given from his letters are often exceedingly amusing. His views on education, freely stated with considerable emphasis in his letters, and his accounts of many journeys abroad, make particularly interesting reading, revealing gifts and powers of an unusual nature in a scientific man, and it is fortunate indeed that the work of a man of such great ability and achievements as Ramsay should be perpetuated in a biography which is really worthy of its subject.

The Nature of Solution. By Harry C. Jones. London: Constable and Co., Ltd. 1917. Pp. xxiii+380. Price 12s. 6d. net.

This volume has been issued as a memorial to the late Prof. H. C. Jones, having been written by him during the last summer of his life, but not published. It contains a sympathetic biographical sketch, by Prof. E. Emmet Reid, of the author who was a man of remarkable energy and force, possessed of the spirit of the time researcher. The text is written in what may perhaps be best described as a semi-popular style, and the general chemist and student would have no difficulty in following it, even if they had very little knowledge of physical chemistry. Like all Prof. Jones's books it is thoroughly interesting, touching upon a wide range of subjects and providing an excellent introduction to the study of more technical works. Considering the fundamental importance not in chemistry only but also in biology and geology of a knowledge of the nature of solutions, it is remarkable that so little is really definitely known of the subject, but it is gradually being placed upon an exact basis, and in no other place in the world has so much been done towards this goal as in the Johns Hopkins Laboratory under Prof. Jones, who acknowledges his indebtness to the Carnegie Institute at Washington. The book contains a short historical outline of the development of our knowledge of the dissolved state of matter, and non-aqueous and mixed solvents are included, while an admirable sketch of colloidal solutions is given. The solvate theory of solutions, to which Prof. Jones made contributions of such great importance, is treated in some detail, and the evidence in favour of the theory is well summarised and explained.

What Industry Owes to Chemical Science. By Richard B. Pilcher and Frank Butler-Jones, B.A., A.I.C. With an Introduction by Sir George Beilby, LL.D., F.R.S. London: Constable and Co., Ltd. 1918. Pp. xiv+150. Price 3s. net.

This book contains a plain and unembellished record of the actual achievements of chemical science applied to industry, which possibly, at any rate up to recent times, have not been recognised at their full value by the world in general. While the triumphs of the engineer are obvious, to all those of the chemist, which are of no less importance to the advance of civilisation, most certainly need chroniclers such as the able authors of this book. It should be of great value and interest to teachers of chemistry as well as students and the parents of students who have to decide upon careers for their sons and daughters and need some knowledge of the outlook and possibilities in various walks of life. Thus, the chapter on Government Chemistry gives an idea of the number and nature of official posts which are to be had, though it obviously does not come within the scope of the book to give details as to qualifications and training. It is undoubtedly true, as the authors assert, that "we have used science more than we realise, but have not talked about it as much as some other people," and this account of the work already done will be surprising to some. Beginning with the metals and treating all the important ones in turn, methods of extraction, purification, &c., are described, allusions being made to the discoverers and to the history of the processes. Other classes of substances—dyes, explosives, paper, leather, &c.—are similarly treated, and a chapter is devoted to the application of chemistry to agriculture. A very interesting chapter on gases, one of the most successful in the book, is included, and a good bibliography is provided.

Pitman's Shorthand Writers' Phrase Books and Guides. Chemical and Drug Trades. Compiled by C. G. A. Cowan, A.C.I.S. London, New York, Bath, and Melbourne: Sir Isaac Pitman and Sons, Ltd. Pp. 76. Price 2s. net.

This book contains some 1500 phrases which are likely to be required by clerks in chemical works and the drug industry, together with the shorthand form for each phrase and useful vocabularies. It also includes specimen letters and extracts of a technical nature which can be used as dictation exercises, and in addition an outline is given of the business methods of the chemical trade, the routine work of office and laboratory, and the duties of shorthand typists in such offices. It will thus be seen that the book is much more than a mere phrase book, and it cannot fail to be of value to the readers for whom it is intended.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Note.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxvi., No. 13, April 2, 1918.

New Metastable Form of Antimony Tri-iodide.—A. C. Vournasos.—Antimony tri-iodide is known to be trimorphic, existing in hexagonal, orthorhombic, and chinorhombic forms. The two last, which are formed at temperatures from 120—125°, are converted into hexagonal ruby-red crystals of the first variety, which is the only form stable up to 600°, the temperature at which decomposition begins. Antimony tri-iodide is slightly soluble in carbon disulphide, glacial acetic acid, and concentrated hydrochloric acid. The author has found that the best solvent is glycerin which, at boiling point, dissolves 20 per cent. From the saturated solution antimony tri-iodide separates as an amorphous powder, which is a fourth metastable variety of this substance. After being washed with anhydrous acetic aldehyde and dried it is a yellow powder which, under the microscope, appears as minute globules. It is soluble in anhydrous acetic acid, and is decomposed by water into antimony oxyiodide and hydriodic acid. When warmed with excess of water it is completely decomposed into Sb_4O_6:—$4SbI_3+6H_2O=Sb_4O_6+12HI$. It is soluble in concentrated hydrochloric acid and is slowly attacked by nitric and sulphuric acids in the cold, iodine being set free. Caustic alkalis and carbonates decompose it into Sb_4O_6 and the corresponding iodides. When heated in absence of air it fuses at 172° and passes into the hexagonal form. To prepare the amorphous variety directly an intimate mixture is made of 10 parts of antimony trioxide with 35 parts of potassium iodide powder, both products being perfectly dry. The mixture is treated with an excess of anhydrous acetic acid. The reaction begins at the ordinary temperature and the powder soon becomes yellow coloured. On heating on the water-bath it is entirely transformed into the tri-iodide, $Sb_2O_3+6HI+6CH_3COOH=2SbI_3+6CH_3COOH+3H_2O$. The acetic acid is then driven off by distillation *in vacuo* or by evaporation, and the amorphous tri-iodide is washed and dried. It keeps better than the crystalline varieties and does not begin to change till about 172°.

No. 14, April 8, 1918.

New Preparation of Methyltoluidines by Catalysis.—Alphonse Mailhe and F. de Godon.—The toluidines can be directly methylated by passing toluidine and methyl alcohol vapour over alumina heated to 350—400°. A liquid is thus obtained which readily separates into two layers. The lower consists of a mixture of water and alcohol containing a little methyl oxide. The upper layer, which can be separated by decantation, is a mixture of monomethyl and dimethyl toluidines, chiefly the latter. If the vapour is passed again over the catalyst all the mono-derivative is converted into dimethyl toluidine.

No. 15, April 15, 1918.

This number contains no chemical matter.

No. 16, April 22, 1918.

Crotonisation of Acetaldehyde; Formation of Butanol and Hexanol from Ethanol.—Paul Sabatier and Georges Gaudion.—Ethanol can be converted into crotonic aldehyde by passing its vapour over reduced copper at 300°, and then, in the same tube, over a catalyst, such as uranium oxide, thorium oxide, or titanic oxide, at about 360°. The ethyl alcohol is first decomposed into aldehyde and hydrogen, and then crotonisation occurs. *A better yield can be obtained by starting with para-aldehyde.* When the products of crotonisation are hydrogenated over nickel the corresponding alcohols, normal butyl alcohol, and normal hexyl alcohol, are obtained.

MISCELLANEOUS.

Obituary.—News has just been received that Lieut. L. J. F. Oertling, R.A.F., who was reported missing on August 8, died on that date from wounds received in action. Lieut. Oertling was in the twenty-seventh year of his age, and was educated at Clifton College, afterwards entering the business of his father, Mr. Henry Oertling, the well known manufacturer of chemical and other types of balances. The deceased officer was an only son, and was married as recently as February of this year. He joined the Inns of Court O.T.C. shortly after the outbreak of war, and obtained a commission in the Bedfordshire Regiment (T.), and proceeded to France with the 8th Battalion. Eventually he became attached to the Royal Flying Corps.

Trade with India and Japan.—Messrs. Laxmichand Dossabhai and Bros., of Bombay, the publishers of the "Indian Directory and Year Book," the "Directory of Merchants and Manufcturers in India," and the "Mercantile Directory of Japan," are making a specíal effort to assist in the promotion of Indian trade with all parts of the British Empire and with friendly countries. With this aim in view they are endeavouring in the new issues of the three Directories to give special prominence to advertisements of English and Colonial firms, and they are prepared to give free trade insertions in the Directories to readers of the Chemical News who are interested in the development of Indian trade with the British Empire. It will readily be recognised that this is an opportunity of which advantage should be taken of replacing goods made by the enemy by those of British origin, and thus furthering British commercial interests both in India and Japan.

NOTES AND QUERIES.

*** Our Notes and Queries column was opened for the purpose of giving and obtaining information likely to be of use to our readers generally. We cannot undertake to let this column be the means of transmitting merely private information, or such trade notices as should legitimately come in the advertisement columns.

Petrol Freezing-point.—Would any correspondent be so good as to supply me with some scientific data? I want to know at what temperature ordinary petrol freezes. I have tried to ascertain this from many journals and books of reference, but have been unsuccessful, and should be much obliged if anyone could inform me.—H. G. Sharman, 58, Elmhurst Road, Reading.

THE CHEMICAL NEWS

Vol. CXVII., No. 3057.

SPECIAL NOTICE TO SUBSCRIBERS.

We regret to announce that the recent paper restrictions will compel us for a period, until we can secure our usual supply of paper, to publish the Chemical News fortnightly instead of weekly.

The price will not be altered, except as regards the subscription price, which, until further notice, will be calculated at £1 for fifty-two numbers, or *pro rata*.

Subscribers will please note that the respective expiration dates of their subscriptions will be extended accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their extended subscription periods.

The next issue (No. 3058) will be published on October 11th.

OBSERVATIONS ON THE RARE EARTHS.

VI. The Purification and Atomic Weight of Dysprosium.

By H. C. KREMERS, B. S. HOPKINS, and E. W. ENGLE.

1. *Introduction.*

The object of the work described in this paper was to further purify dysprosium material already in a high state of purity. This purification was preliminary to a later object, namely, a further study of the atomic weight of dysprosium by the use of the oxide-chloride ratio as used by Engle and Balke (*Journ. Am. Chem. Soc.*, 1917, xxxix., 53), and by a comparative study of this ratio with other ratios.

2. *History of Dysprosium.*

Our knowledge of the chemistry of dysprosium is very limited, and but little concerning the element is found in the literature. In 1878 Delafontaine (*Comptes Rendus*, 1878, lxxxvii., 559) announced a new element, philippia, giving a strong absorption band (=451·5). In 1880 Delafontaine found that this band was the same as that described by Soret and Cleve for holmium. During the same year Soret (*Comptes Rendus*, 1880, xci., 378) announced that the philippia of Delafontaine and his holmium were the same and that the substance contained one body. In 1880 Lecoq de Boisbaudran (*Comptes Rendus*, 1886, cii., 1003; Chemical News, 1886, liii., 265) by means of several hundred fractionations with ammonia and potassium sulphate succeeded in separating the supposed holmium of Soret into two elements. The element giving the absorption maxima, =753, 475, 451·5, and 429·3, was called dysprosium.

It was not until 1916 that Urbain obtained some 50 grms. of dysprosium oxide by fractionation of the ethyl sulphates and nitrates (*Comptes Rendus*, 1906, cxlii., 785). An extensive study of the absorption spectra of the element was also made by the same author. The present accepted value of the atomic weight of dysprosium was determined by Urbain and Demenitraux (*Comptes Rendus*, 1906, cxliii., 598). According to these authors the ratio which gave the most concordant results was the transformation of the octohydrated sulphate, $Dy_2(SO_4)_3.8H_2O$, into the oxide, Dy_2O_3, by ignition at a white heat. As a mean of 12 determinations the value 162·54 was obtained as the atomic weight. Their greatest variation was between 162·29 and 162·75. Some fifteen compounds of dysprosium have been studied by Bourion (*Comptes Rendus*, 1907, cxlv., 243; *Ann. Chim. Phys.*, 1910, [8], xxi., 77), Urbain and Jantsch (*Comptes Rendus*, 1908, cxlvi., 127), and Jantsch and Ohl (*Ber.*, 1911, xliv., 1274). The atomic number of dysprosium, according to the table arranged by Mosley (*Phil. Mag.*, 1914, xxvii., 703), is 67, placing it between holmium 66 and erbium 68. Dushman (*Gen. Elec. Rev.*, 1913, xviii., 614) states that the order of the atomic numbers of dysprosium and holmium in Mosley's table is apparently the reverse of that of the atomic weights. Harkins and Hall assign 66 as the atomic number of the element (*Journ. Am. Chem. Soc.*, 1916, xxxviii., 2). Durrant also assigns the same number to dysprosium (*Journ. Am. Chem. Soc.*, 1917, xxxix., 621).

3. *Fractionation of the Bromates for the Purification of Dysprosium.*

In the fractional crystallisation of the yttrium group bromates, by Engle and Balke (*loc. cit.*), dysprosium bromate was obtained containing 1 or 2 per cent of holmium, small amounts of neodymium, praseodymium, and traces of terbium. This series was further fractionated as the bromates, during which time fractions were removed from the insoluble end as the neodymium and praseodymium collected here. As the holmium concentrated toward the soluble end these fractions were removed from time to time. These bromates were run through 125 series of recrystallisations. A careful spectroscopic examination indicated faint traces of neodymium and praseodymium in the least soluble fractions. The colour of this oxide was slightly buff. Holmium was found in all of the fractions, being more concentrated toward the soluble end. Since the amount of holmium present was estimated to change the atomic weight of the dysprosium no more than two or three units in the second decimal place it seemed that this material was sufficiently pure for an accurate determination of the atomic weight. Accordingly, Samples 7 and 8 (table of results) were selected from this series.

The bromate fractionation was not wholly ideal in the final purification of dysprosium; neodymium and praseodymium concentrated slowly toward the less soluble end, and the last traces of holmium were not removed by this method.

4. *Fractionation of the Ethyl Sulphates for the Purification of Dysprosium.*

It seemed highly desirable that the two ethyl sulphate series, which had been fractionated by Engle and Balke (*loc. cit.*) for the separation of dysprosium, be further fractionated with the hope that the last impurities might be removed. It was found that most of the fractions of the two above mentioned series had hydrolysed during the warm summer months, and the majority of the fractions had to be recovered. The individual fractions were precipitated with oxalic acid, ignited to the oxide, and weighed. The calculated amount of ethyl sulphuric acid was added to each oxide and agitated until complete solution had taken place. Absolute alcohol was used as the solvent in the fractionation of these series, and the crystallisation was allowed to take place in a refrigerator in which the temperature was 9°. By this method a temperature of 30—40° was sufficient to dissolve the crystals, and by keeping the fractions at this low and constant temperature during crystallisation very little hydrolysis took place.

* Part of a thesis submitted by H. C. Kremers to the Graduate School of the University of Illinois as partial fulfilment of the requirements for the degree of Doctor of Philosophy. From the *Journal of the American Chemical Society*, xl., No. 4.

The first ethyl sulphate series, as left by Engle and Balke, contained a fraction of 1 per cent of terbium with slight amounts of neodymium and praseodymium toward the less soluble end. Holmium was found in all the fractions. This series was fractionated 65 times. Very nearly all of the neodymium and praseodymium had been removed during this time. A small amount of terbium was still present. The holmium could not be removed by this method.

The second ethyl sulphate series contained besides the dysprosium very small amounts of terbium. This series was fractionated in the same manner as the first ethyl sulphate series with the hope that the last traces of terbium might be removed. After 60 recrystallisations it was found that some terbium still remained although a considerable amount had concentrated toward the insoluble end.

A comparison of the bromate and ethyl sulphate methods of fractional crystallisation shows that the ethyl sulphates were more efficient for the removal of terbium, neodymium, and praseodymium from dysprosium. Neodymium, praseodymium, and terbium were removed only very slowly by the bromate method. By neither of the methods could all of the holmium be removed, although the bromates were the best suited for this purpose.

5. *Preparation of Reagents Used in the Atomic Weight Determinations.*

Water.—The ordinary distilled water was redistilled, after the addition of alkaline permanganate, from the still used in this laboratory for the preparation of conductivity water. The water thus prepared gave no test for chlorine by the most delicate nephelometric test.

Nitric Acid.—C.P. nitric acid was redistilled from quartz apparatus. The middle third was collected in a quartz flask and reserved for use. The acid thus prepared gave no test for chlorine.

Oxalic Acid.—C.P. oxalic acid was dissolved in hot water, filtered, and recrystallised twice from conductivity water containing 10 per cent redistilled nitric acid, and, lastly, from conductivity water. Each yield was drained in a porcelain bowl centrifuge.

Hydrochloric Acid.—Concentrated C.P. hydrochloric acid was heated in a quartz distilling flask and the vapours passed over conductivity water in a quartz flask.

Hydrogen Chloride.—This was prepared by dropping concentrated C.P. sulphuric acid into a concentrated solution of C.P. hydrochloric acid. The gas was dried by passing through two towers, 1 metre high and 2·5 cm. in diameter, filled with glass beads which were kept moist with concentrated C.P. sulphuric acid. The entire apparatus was of glass and was continuous.

Nitrogen.—Air was saturated with ammonia by bubbling through a wash-bottle containing concentrated ammonium hydroxide solution, and passed through a quartz tube filled with copper gauze, heated to redness by means of an electric furnace. This nitrogen was bubbled through dilute sulphuric acid to remove the excess of ammonia. The gas was purified by passing through a train composed of vertical towers 60 cm. high and 2·5 cm. in diameter. The first tower contained solid glass beads moistened with dilute sulphuric acid. The second tower contained glass beads moistened with 5 per cent silver nitrate solution. The third tower contained glass beads moistened with C.P. concentrated sulphuric acid. The fourth tower contained solid sticks of potassium hydroxide. The fifth tower contained glass beads and concentrated sulphuric acid, and, lastly, the gas passed through a tube containing glass-wool interspersed with freshly sublimed phosphorus pentoxide.

Air.—Air was purified in the same manner as was the nitrogen.

The purifying trains for hydrogen chloride, nitrogen, and air were all mounted in a compact form on a wooden frame. All connections were made of glass or ground-glass joints. This apparatus was also used by Engle and Balke (*loc. cit.*) in their investigation on the atomic weight of dysprosium.

Silver.—The silver used in this investigation was prepared in essentially the same manner as that used by Richards and Wells in their investigation on the atomic weights of sodium and chlorine (*Pub. Carnegie Inst.*, 1905, xxviii.).

Thirteen hundred grms. of C.P. silver bromide were reduced by a dry fusion composed of the following charge:—Eight parts sodium carbonate, eight parts potassium carbonate, three parts of silver bromide, and one part of flour. This mixture was fused in fire-clay crucibles in a large gas-fired pot furnace. The melt was poured into conical iron moulds, the silver buttons collecting in the bottom. These silver buttons were cleaned, etched with nitric acid, washed and dissolved in nitric acid. The silver nitrate was recrystallised three times from redistilled nitric acid and conductivity water. The crystals were drained in each case by means of a high-speed centrifuge. The silver nitrate solution was next reduced with freshly-prepared ammonium formate and washed several times by decantation. The silver placed in large porcelain crucibles lined with pure carbon was fused in an electric furnace (Richards and Wells, *Ibid.*). The silver buttons were carefully cleaned, etched with nitric acid, washed, dissolved in redistilled nitric acid, and again reduced with ammonium formate. The reduced silver was washed by decantation with conductivity water and fused in large porcelain crucibles lined with pure lime in an electric furnace (Richards and Wells, *loc. cit.*). The silver thus obtained was carefully cleaned with a stiff brush, etched, washed, and electrolysed, using a bar of pure silver as the cathode (Sears and Balke, (*Journ. Am. Chem. Soc.*, 1915, xxxvi., 833). The fused silver was used as the anode and silver nitrate, made by dissolving some of the fused silver in nitric acid, formed the electrolyte. By carefully regulating the strength of the current a well crystallised deposit of silver was obtained. This electrolytic silver was well washed with conductivity water, dried, and fused in large unglazed porcelain boats lined with pure lime. This final fusion was carried out in a porcelain tube electric furnace in an atmosphere of pure hydrogen, prepared from zinc and hydrochloric acid, and purified by passing through wash towers containing alkaline permanganate, silver sulphate, solid potassium hydroxide, and, lastly, through a quartz tube containing heated platinised quartz, and a tube of glass-wool interspersed with freshly sublimed phosphoric anhydride. Bars of silver weighing some 50 grms. each were obtained, and were carefully cleaned, etched, washed, and dried, and preserved in a desiccator over solid potassium hydroxide. Before weighing the samples for analysis these bars were cut into pieces, etched to the desired weight, and washed with conductivity water, absolute alcohol, and ether, and heated to 120° for some minutes.

All vessels used in the preparation of the reagents, described above and in the work following, were of platinum, quartz, or Jena and Non Sol resistance glass.

6. *Preparation of Dysprosium Oxide.*

The dysprosium oxide for the analysis was prepared as follows:—The alcoholic solution of the ethyl sulphates were diluted with water, a few cc. of dilute sulphuric acid added, and heated to boiling. All the barium, from the small amounts of barium ethyl sulphate present in the series, was removed as barium sulphate. The dysprosium was then precipitated with oxalic acid. The fractions from the bromate series were first precipitated with ammonia, washed, dissolved in nitric acid, and from this point on the purification was the same as that of the material from the ethyl sulphate series. Several alternate precipitations with ammonia and oxalic acid were given to each sample. The ammonia precipitation was carried out by passing ammonia gas over the nitrate solution diluted to 1 litre and agitated until precipitation was complete. The hydroxides were washed by decantation. When

washing was complete the hydroxides were dissolved in nitric acid diluted to 1 litre and heated to boiling. A hot solution of dilute oxalic acid was added slowly up to the point when precipitation began. By allowing the solution to cool a crystalline precipitate was obtained which was easily washed. After washing the oxalate was dried in an electric oven and ignited in platinum if another ammonia precipitation was desired. Each sample was precipitated three or more times with ammonia and usually the same number of times with oxalic acid, the last precipitation always being as the oxalate. The last precipitation in each case was carried out by the use of redistilled nitric acid and conductivity water. The final oxalate was ignited for several hours in platinum in an electric muffle furnace at a temperature of 800°, and, lastly, for an hour at 900°.

7. The Ratio of Dysprosium Sulphate to Dysprosium Oxide.

The ratio mentioned above was used by Urbain and Demenitraux, upon whose work the present accepted value is based (*Comptes Rendus*, 1906, cxlii., 785). A sample of dysprosium was prepared by Engle and Balke in the same manner as prepared by the authors mentioned above. This in brief was as follows:—The concentrated sulphate solution was precipitated with a large excess of alcohol. This sulphate was washed with absolute alcohol, dissolved in water, and crystallised on a steam-bath. The sulphate was dried over sulphuric acid in a desiccator. Urbain and Demenitraux claimed that the pure octohydrated sulphate, $Dy_2(SO_4)_3.8H_2O$, was obtained in this way.

An alundum crucible was ignited to constant weight in a platinum wound muffle furnace at a temperature of 1200°, and 1·33843 grms. of the sulphate, which had been dried over sulphuric acid for twelve months, was weighed out. This was ignited to constant weight, giving 0·66955 grm. as the weight of the oxide. This indicates an atomic weight of 173·291. From this determination it would seem that a partial dehydration of the sulphate had taken place in the desiccator. Hopkins and Balke (*Journ. Am. Chem. Soc.*, 1916, xxxviii., 2332) in their work on the atomic weight of yttrium found that the hydrated yttrium salts were not stable when kept over sulphuric acid, calcium chloride, or partly dehydrated yttrium salts. The investigation of the dysprosium sulphate was not carried further, since it did not appear that a hydrated sulphate of constant composition could be obtained under the present conditions.

8. The Ratio of Dysprosium Oxide to Dysprosium Chloride.

The method of procedure used here was essentially the same as that used by Egan and Balke in their study of a similar ratio for yttrium (*Journ. Am. Chem. Soc.*, 1913, xxxv., 365). Practically the same apparatus used in this work was used by Engle and Balke (*loc. cit.*) in their investigation on the atomic weight of dysprosium. The oxide while still hot from the ignition was transferred to the 25 cc. quartz reaction flasks, the caps quickly adjusted on the inlet and outlet tubes, and the flask cooled in a desiccator. The flask was hung in the balance case for three hours or more and weighed. Just before weighing one of the caps was loosened for a moment to equalise the pressure. The oxide was dissolved by addition of hydrochloric acid and warming. No effervescence or spattering was noticed. The quartz reaction flask was then attached to the purifying train by two ground glass joints, one serving as an inlet and the other as an outlet for the gases. The purifying train was so constructed that air, nitrogen, hydrogen chloride, or a mixture of any two or all of the gases could be passed into the flask at will. The procedure from this point on was varied somewhat from that used by Engle and Balke. An especially constructed oven made of asbestos wood 0·25 inch thick was used to heat the flask. The inside dimensions were 4×6×7 inches, and mica windows were placed in two opposite sides. Coils of nichrome resistance wire served as the heating unit, and by means of outside resistance any constant temperature up to 360° could be maintained. This oven could be placed around the flask after it was attached to the train, in such a manner that the entire flask together with the inlet and outlet tubes was enclosed and entirely protected from the laboratory gases. The various stages of the dehydration could be observed through the mica windows without disturbing the flask. Air was first passed through the flask while the temperature was 110—115°. When the salt began to crystallise hydrogen chloride was mixed with the air until the salt had completely crystallised and dehydration had begun to take place. The air was now stopped and only hydrogen chloride passed through. At this point Engle and Balke passed nitrogen through the flask together with the hydrogen chloride. It was found that nitrogen could be omitted without any difficulty. As the dehydration took place the temperature was gradually raised to 125—130° and kept at this point until water ceased to escape. The temperature was raised to 200°, at which the last molecule of water of crystallisation began to come off, the dehydration becoming complete at 230°. From this point on the temperature was gradually raised to 350°, and the oven then replaced by a small muffle furnace. When the temperature had reached a dull red the current of hydrogen chloride was stopped and the chloride fused with the Bunsen flame. In the last four determinations the chloride was fused by means of the electric furnace. After the flask had cooled somewhat the hydrogen chloride was replaced by dry air. With the exception of Samples 1 and 2 the exit air, from the displacement of the hydrogen chloride, was finally bubbled through silver nitrate solution until no further test for hydrogen chloride could be obtained. This insured the absence of all hydrogen chloride in the flask. When the flask had cooled to room temperature the outlet tube was first disconnected from the train and the cap adjusted. While the air was still passing, the inlet tube was disconnected from the train and the cap quickly adjusted, thus preventing the entrance of any moist air. The flask was hung in the balance case for several hours and weighed.

The dysprosium chloride formed in this manner dissolved completely in cold water to a clear solution. The dysprosium chloride solution from a preliminary run gave the following reactions toward several indicators:—The solution was basic toward rosalic acid, basic to methyl-orange, slightly acidic to congo-red, slightly basic to cochineal, neutral to litmus, and slightly acidic toward methyl-red. These reactions indicated that the hydrogen-ion concentration of the solution was $10^{-5 \text{ or } 6}$ (Washburn, "Principles of Physical Chemistry," 1915, p. 333).

Nine consecutive determinations were made. Samples 1 and 2 were taken from the soluble end of the second ethyl sulphate series. The oxides were slightly coloured.

Sample 3 was taken from near the centre of the second ethyl sulphate series. The oxide gave a slightly deeper colour than Samples 1 and 2. This deeper colour was due to the presence of more terbium.

Samples 4, 5, and 6 were obtained from the second ethyl sulphate series after 60 recrystallisations by Engle and Balke. Sample 5 was ignited at 900° for eight hours.

Sample 7 was obtained from the less soluble end of the bromate series. The oxide was slightly coloured.

Sample 8 was obtained from the middle of the bromate series. The oxide was nearly white, showing very little terbium to be present.

Sample 9 was also obtained from the insoluble end of the second ethyl sulphate series of Engle and Balke. After ignition for eight hours at 850° a light buff-coloured oxide was obtained. When this was ignited in pure hydrogen for three hours at a temperature of 250° the oxide became pure white. This indicated that the buff colour was due to the terbium, present as a higher oxide. The ignition in hydrogen reduced this terbium to the trioxide, Tb_2O_3. The atomic weight of this fraction was not much different from that of the others. By strong

ignition in hydrogen a slate-coloured oxide was formed which left a black residue upon solution in acids. When ignited at a lower temperature this slate-coloured oxide was not formed. Bettendorf described the same phenomenon as taking place when gadolinium oxide, containing traces of terbium, was ignited in hydrogen (*Ann.*, 1892, cclxx., 376).

All weighings were made on a Ruprecht balance, used exclusively for atomic weight work. This balance was kept in a special cork insulated room, the temperature of which remained constant to within 2°. All weighings were made by the method of substitution, the tare flask being of quartz similar in size and shape to the reaction flask and differing from it in weight by only a few mgrms. The weights were carefully standardised to 0·01 mgrm., and all weights were corrected to vacuum standard. The specific gravity of the weights was taken as 8·4, that of dysprosium chloride as 3·67 (Burion, *Comptes Rendus*, 1907, cxlv., 243), and that of dysprosium oxide as 7·81 (Engle and Balke, *loc. cit.*). The atomic weight of oxygen was taken as 16 and that of chlorine as 35·46. The following values were obtained by this ratio:—

Sample.	Weight of Dy_2O_3.	Weight of $DyCl_3$.	Ratio $Dy_2O_3 : DyCl_3$.	Atomic weight.
1.	0·72974	1·04979	1 : 1·43859	163·83
2.	1·36017	1·95604	1 : 1·43808	164·05
3.	0·69716	1·00255	1 : 1·43804	164·06
4.	1·02493	1·47475	1 : 1·43887	163·71
5.	0·87688	1·26253	1 : 1·43979	163·31
6.	0·69318	0·99677	1 : 1·43796	163·10
7.	1·55248	2·23374	1 : 1·43882	163·72
8.	0·83958	1·20763	1 : 1 43837	163·92
9.	1·56481	2·25129	1 : 1·43869	163·78
		Mean		163·83

(To be continued).

THE
BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

In spite of the obvious difficulties of arranging an exhibition at the present moment the British Science Guild has achieved signal success in its enterprise. Forced to rely mainly upon voluntary contributions they have nevertheless succeeded in bringing together a remarkable collection of substances and appliances of scientific and commercial interest, and it is encouraging to find that manufacturers and scientific men have been public-spirited enough to give financial support to an undertaking from which they could hope to get no immediate material return. The aim of the organisers of the exhibition was mainly to enlightening the public as to the efforts made by British science and industry to meet the requirements of both our home and foreign markets by the production of goods and materials which prior to the war were made chiefly in enemy countries. Difficulties of transport and labour have both tended to prevent the exhibition from being made really representative, and in some cases it was clearly not expedient to make public some of our most notable achievements, but the exhibition is a sufficiently striking tribute to our national alertness and enterprise, and though we cannot yet be said to have recovered the place in industry which should be ours in view of our resources and abilities it cannot be denied that we have made enormous strides in particularly difficult circumstances during the last four years. There is much still to be done, but in nearly all branches remarkable progress has already been made, and we are well on the way towards overtaking our competitors.

The exhibits were classified in fourteen sections, and in nearly every section there is the same tale to be told of British inventiveness giving us the possibility of taking the lead, which, however, was lost to us owing to a combination of causes which have perhaps now been sufficiently thoroughly analysed and discussed. In almost every case we were face to face with a disastrous prospect at the outbreak of war, but the determination and energy of our manufacturers are gradually improving the position, and the outlook for the future is becoming brighter every day.

The first section comprised Chemical Products, and here particularly gratifying advances are to be recorded. The well-arranged exhibits show that we are successfully manufacturing fine chemicals and drugs for which we were previously entirely dependent on Germany, and at the same time we are introducing new products as the results of the researches of chemists in British laboratories. Some firms have the satisfaction of showing that while their normal trade is developing well, they are also recapturing trade which has comparatively recently been abandoned as unremunerative in face of German competition, and are also undertaking the manufac ure of new substances as an outcome of new demands created by the war. It is most satisfactory to see British products which have entirely replaced those obtained from the Continent before the war, and in all directions substantial progress has been made.

In the section which included Physical Appliances special attention may be called to a new British-made portable pyrometer, which is very easy to read and simple in construction, and is based upon an entirely new principle. German thermometers are also gradually being displaced from British laboratories, it is to be hoped for ever, while there has been an enormous development in our manufacture of optical apparatus since 1914. Besides articles which are now made in great numbers for direct use in warfare—telescopes, searchlights, periscopes, &c.—refractometers and saccharimeters are now produced in England which possess obvious advantages over and are much superior to those made in Germany. Magnetos, which before the war might have been regarded as practically a monopoly in the hands of the Germans, are a most important feature among the electrical appliances. All types of models, suitable for aeroplanes, motor cars, cycles, &c., are now made in England, and are quite as good as, if not better than, the formerly universally used Bosch magnets. Another interesting exhibit in this section is the optophone, an instrument which enables a totally blind person to read by ear any ordinary book or newspaper. Rapidly intermittent light is thrown upon the letterpress and reflected on to a piece of selenium, by means of which the reflected light is converted into sound by a telephone. Each letter of the alphabet has its own characteristic sound. Thus, any print can be read in any language by ear alone. Examples were given of the possibilities of the instrument, and of the reading of the blind after comparatively few lessons in its use. Possibly the greatest advances have been made in the manufacture of glass, and it is perhaps not premature to congratulate our manufacturers upon having really triumphed over all difficulties and laid the foundation of a valuable and developing industry. According to some statements before the war only 20 per cent of the glass used in Great Britain was made at home, and at first British manufacturers seemed to be almost unable to cope with the situation. Gradually, however, the country's needs, especially in optical glass and chemical glass, were realised, and manufacture was begun in earnest. The result has been the production of glass and apparatus equal or even superior to the best made abroad. For example, a glass is now made in Great Britain which is more resistant to acids and alkalis than Jena glass, and the lamp-blowing industry, which in pre-war days was practically unknown in this country, is now firmly established. Scientific investigations dealing with problems in glass manufacture are in full swing, and manufacture has been speeded up to such an extent that a British firm can boast of supplying the needs of our

Allies as well as being able to meet home requirements. Special courses in glass manufacture at technical schools and universities are well attended, and there is a great demand for theoretical and practical instruction in the subject. Great progress has also been made in the manufacture of quartz glass, and an interesting exhibit shows many varied pieces of apparatus now made in this valuable material.

Section IX., which comprises papers of all kinds, was of special interest to the general public, by whom perhaps it has not been realised that paper socks, helmets, jackets, string, bootlaces, towels, &c., are now being manufactured, as well as drinking cups and containers for various food products, and the tenth section —Textile Specialities—also attracted many visitors. All kinds of textiles previously made only in Germany and now produced here were exhibited, and specimens of the work of British dyers show that most satisfactory results have already been obtained, with the promise of still greater developments in the future. There is need for a great extension of educational facilities in the Textile Industries, and much research work is waiting to be done. Inducements must be offered to students to devote themselves to the subject if Great Britain is to maintain its position, especially as regards the higher class products, and our progress in the dyeing industry must keep pace with that in textiles.

One comparatively small section—that of Food Products—inevitably awakens in the mind comparisons with Germany and the reflection that here at least our backwardness may be regarded as a matter for congratulation. There were no exhibits of substitutes for articles of food, with the exception of margarine, and British inventiveness has most fortunately not had to expend itself in this direction.

The Munitions Inventions Department of the Ministry of Munitions had an exhibition which showed some of the results which have accrued from the research undertaken on the nitrogen problem. This took the form of a unit plant for the oxidation of ammonia to oxides of nitrogen. This process was not in extended use outside Germany before the outbreak of war, but there is reason to believe that the Germans have relied on it very largely for their output of nitric acid for explosives as well as in the manufacture of sulphuric acid by the chamber process, as a substitute for Chile nitrate, which, owing to our blockade, they have been unable to obtain. The method is now in use in this country, and several large firms, such as Brunner, Mond, and Co., Ltd., and the United Alkali Co., Ltd., are using apparatus similar to that shown. The apparatus was on view continually during the Exhibition, and demonstrations were given by an officer of the Munitions Inventions Department.

In this short summary of the chief features of the exhibition many interesting and important exhibits have had to be ignored, and in such an account of it it is impossible to give anything like an adequate idea of its scope, just as the organisers have not been able to do more than indicate the lines along which science and industry are together moving. It is possible that enough stress has now been laid upon our neglect of science and our errors in the past, and there has been enough talk of what we have failed to do and the reasons for our failures, and the constructive period has dawned. What we have already done is nerving us to fresh efforts, and self reproach may be put away; the cry "We have failed" may be replaced by "We are succeeding."

The establishment of research associations, such as the British Photographic Research Association and the British Scientific Instrument Research Association, is part of a larger scheme from which there is much to be hoped, and provided that the needs of scientific education are not neglected and there is a good supply of well-trained men and women to undertake the work, these associations should prove most effective means of benefiting industry.

From every point of view the Exhibition was stimulating and encouraging, and the Committee of Organisation and exhibitors may congratulate themselves upon having done a service to the nation which to all appearances was exceedingly well appreciated by the public.

ROYAL SOCIETY.

Memorandum of Committee on International Scientific Organisations.

(Concluded from p. 287).

Group II.

1. *The International Geodetic Association* was formed by twenty-one contributing States, and has an annual income of nearly £3000, the subscriptions for the larger States being £300. According to its convention, which held for twelve years at a time, and was renewable, the Prussian Geodetic Institute at Potsdam was its Central Bureau. Its President, Vice-President, and Secretary belonged to different countries, and retained their position for the duration of the convention, which lapsed in 1916. Its most useful work concerned the standardisation and comparison of pendulums for gravity measurements. In its later years it devoted itself almost entirely to investigations on changes of latitude.

2. *The International Seismological Association* was formed in 1903 on the pattern of the Geodetic Convention, the Imperial Seismological Station at Strassburg being selected as the Central Bureau. France, the United States, and Great Britain at first refused to join this association, and the International Association of Academies appointed a Committee to suggest such alterations in the proposed convention as would enable these countries to take part in the work. The principal changes proposed and ultimately accepted were (1) that Strassburg should not necessarily remain the Central Bureau, the selection of its domicile being left to the triennial meetings; (2) that the President should only hold office for three years; (3) that a State may join through one of its scientific societies, and not necessarily through its Government; and (4) that the correspondence between the President and the organisations in each State be carried out through the Secretary of the Association and not through diplomatic channels as originally provided. The United States joined as soon as these changes were accepted; France and Great Britain a few years later. The organisation then consisted of twenty States, with an annual income of £1700; the larger States contributing £160 annually. The principal work of the Bureau consists in receiving and distributing information and publishing systematic lists of earthquakes. Part of the funds are used in paying scientific workers appointed by the association for the purpose of carrying out special researches. The convention lapsed in 1915.

3. *International Commission for the Telegraphic Distribution of Astronomical Information.*—This was at the beginning an apparently self-constituted body of the directors of the principal astronomical observatories in Europe which arranged for the telegraphic distribution of astronomical information. The preliminary arrangements were confirmed by a meeting of astronomers held in Vienna in 1883, when formal statutes for the future conduct of the work were adopted. The headquarters of the organisation are at Kiel. The office and working expenses are met by subscriptions from the observatories receiving the information. These were originally fixed at £6 annually, but were subsequently reduced owing to the facilities given by cable companies, which transmit a certain number of messages without charge.

4. *The International Permanent Agricultural Institute.*—This is the outcome of an international meeting held at Rome during 1905 on the invitation of His Majesty the King of Italy. The Institute has its permanent seat at

Rome, and its constitution follows lines similar to those of other international conventions. The business is conducted by a General Assembly, meeting occasionally, and a Permanent Committee. The principal object of the Institute is to collect, publish, and disseminate statistical information relating to Agriculture, to notify new diseases in plants, and to present, if expedient, to the Governments, for their approval, measures for the protection of the common interests of agriculturists. Questions relating to the economic interests of particular States are excluded. The convention differs from that of other international organisations in so far as no time limit is fixed for its duration, and that the voting power of different States varies according to the money contributions. The meetings are apparently always held at Rome.

5. *International Council for the Exploration of the Sea.*—This was constituted in 1902 as a result of discussions held at conferences meeting in Stockholm and Christiania in 1899 and 1901 respectively. It confined itself to questions relating to Sea Fisheries in North-European seas, and developed as an economic and political, rather than a scientific, movement. The headquarters were at Copenhagen. The countries originally adhering to the convention were Denmark, Germany, England, Finland, Holland, Norway, Russia, and Sweden. The first convention was made for five years, but annual meetings continued to be held. A number of Committees were appointed to deal with different branches of the work. Large sums of money were spent on the work; the total contribution of England amounted to £70,000 (£14,000 annually). The organisation seems still to be in existence, but cannot properly now be called an international undertaking.

6. *The Marey Institute.*—This Institute was founded by M. Marey for the standardisation and improvement of instruments used in physiological researches. Its laboratory is at Paris, and its work is controlled by an International Committee. The French Government contributes annually 25,000 francs, and the Swiss Government 1000 francs. In addition, occasional money contributions are made by the Academies of Paris, Leipsic, and Petrograd, as well as the Royal Society and the University of London.

7 and 8.—*The Solar Union and the Scientific Sub-Committees of the International Meteorological Committee* are entered both under Groups I. and II., because their activity includes to a considerable degree scientific investigation as well as standardisation.

9. The International Committee for the Investigation of the Brain. (See under International Association of Academies, Group IV.).

Group III..

1. *The International Astrographic Chart.*—The idea of forming a detailed photographic chart of the heavens originated with Sir David Gill, but the organisation for its practical execution is mainly due to the efforts of Admiral Mouchez, who at the time was Director of the Paris Observatory. Its programme of work was determined upon at an International Conference held in Paris in 1887. The photographs are taken at eighteen observatories, of which six are in Great Britain and its colonies, four in France and its colonies, two in Italy, one each in Germany, Finland, and Chili. Each country pays the expenses of its own observatories.

2. *Carte Internationale du Monde au Millionième.*—The proposal to issue a map of the world on a uniform plan was initiated at a conference held in London in 1910. In this conference only those countries took part who were represented by ambassadors at the Court of St. James's. A second conference, in which other countries also took part, was held at Paris in December, 1913. Further details with regard to the construction of the map were settled, and it was resolved that a permanent central office should be established in England for the communication of data, interchange of information, and the publication of an annual report. The headquarters of the office were to be at the Ordnance Survey, Southampton, with an auxiliary office in London.

3. *The International Catalogue of Scientific Literature.*—This catalogue, which begins with the year 1901, has its central office in London. Twenty-nine countries (counting the four Australian colonies separately) participate in the work, and most of them have established Regional Bureaux for the preliminary work of preparing the slips which are transmitted to England. The annual office expenses amount to over £2000, while the expenditure in printing and publication is about £5000. These expenses are approximately covered by the guarantees of different countries, which take the form of subscriptions for copies of the work, and the independent sales. To estimate the total cost of the catalogue it would be necessary to add to the expenses of the Central Bureau those of the Regional Bureaux of the different countries.

Group V.

The International Association of Academies.—The foundations of this Association were laid at a conference held at Wiesbaden in 1899, the following Academies being represented:—Berlin, Göttingen, Leipzig, Münich, Paris, Petrograd; Vienna, Washington, and the Royal Society of London. Meetings have been held at Paris (1901), London (1904), Vienna (1907), Rome (1910), and Petrograd (1913).

Since then the following have been added:—Amsterdam, Bruxelles, Budapest, Christiania, Edinburgh (Royal Society), Geneva (Société Helvétique des Sciences Naturelles), Helsingfors, Copenhagen, London (British Academy), Stockholm, Tokyo, and Washington. The Institut de France is represented by its three component bodies: the "Académie des Inscriptions," the "Académie des Sciences," and the "Académie des Sciences Morales et Politiques." The annual contribution is fixed at 200 francs.

This International Association is intended to initiate work in which several academies are interested, and to advise the Governments on new international undertakings. At the London meeting the following resolution was passed by 19 votes against 1, the dissenting Academy being that of Berlin:—"That the initiation of any new International Organisation, to be maintained by subventions from different States, demands careful previous examination into the value and objects of such organisation, and that it is desirable that proposals to establish such organisations should be considered by the International Association of Academies before definite action is taken." In accordance with this resolution the International Association has from time to time extended its protection towards undertakings such as the Solar Union, the Marey Institute, and the International Committee for the annual publication of Tables of physical and chemical Constants.

Its scientific work was carried out through Committees, and if these were of a permanent character the provision was made to give them an autonomous existence. In that case the Committee could act on its own responsibility, reporting its action at a subsequent meeting of the Association. The only Committee which received this status was that which dealt with the Functions of the Brain. The investigations of this Committee were carried out at special institutions established in different countries which combined for the purpose. According to the latest report presented at Petrograd in 1913 it was intended to issue an Atlas of the Central Nervous System, and to make efforts to introduce a uniform nomenclature.

The agreement establishing this Association was not limited as regards time, so that it can only come to an end by a resolution embodying a change of statutes which would have to be carried by a two-thirds majority. The combined academies of the Allied Countries and Russia have 11 votes out of a total of 24, and all the neutral countries (including Finland) would have to combine to

bring the Association to an end, except by consent of the Central Powers. Any Academy is, of course, at liberty to withdraw from the Association.

REPORT OF THE COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH FOR THE YEAR 1917-18.*

This is the third annual Report of the Research Department established by the Government for the purpose of encouraging research and assisting the Scientific investigation of industrial problems.

The Report of the Committee of the Privy Council for Scientific and Industrial Research, which precedes the Report of the Advisory Council, contains a summary of the year's expenditure and of the more important questions of policy involved.

The most important section is that in which the policy of the Department with regard to Research Associations is set out fully. This reads as follows:—

"It is open to an industry to establish an improved association without seeking assistance from parliamentary funds, and associations of this kind will have exactly the same privileges and will receive the same assistance in the way of advice and information, as associations in receipt of grant. The Department has found in the course of its conversations with leading manufacturers that there is sometimes a certain hesitancy to establish relationship with the Government for the purposes of research, because they fear that the Department will interfere in the work of the new associations, and will use its powers in such a way as to prevent the results of research from reaching the firms which have subscribed to its cost, or to give the results to competing firms which have not joined or have left the association. In general they seem inclined to believe that they are being invited to submit to a departmental yoke, which, especially if it is embellished with gold, will grow heavier and fit closer as time goes on, until at last the too complacent trade will find itself harnessed to the Government car, and led, if not driven, at the will of the paymaster. Such an issue would be fatal to the success of our scheme, and entirely opposed to the policy our Advisory Council have formulated and we have approved. Our intention is that the Associations shall manage their own affairs and benefit by their own discoveries. We believe that the Department can help each by keeping it in touch with the work of the rest; that the limitation of Government grants, in all ordinary cases, to a short period of years, and the provision under which an Association can either forego grants altogether or abandon them at any time, are evidences of our intention. The power of the Department to interfere in cases in which the national interest is concerned or in which the funds provided by Parliament are not being used for the purposes for which they were granted is surely the minimum safeguard that a democratic country could require. But if the firms in an industry will undertake research either for themselves or in combination on any other plan which they think better suited to their needs, they will as certainly receive the sympathetic consideration of the Department and such assistance as is in its power to render. We have never thought that the industrial research association would meet the case of all industries. But the receipt of public funds must entail the performance of public duties, and for these the Department must have a care."

* To be purchased through any bookseller or directly from H.M. Stationery Office, Imperial House, Kingsway, price 4d.

The first part of the Report of the Advisory Council deals mainly with the progress which is being made in the establishment of Research Associations by industries which are preparing to undertake co-operative scientific research for the benefit of members of the Association.

Some thirty industries are doing preliminary work with this object, and the Photographic industry, the Scientific Instrument making industry, the Portland Cement industry, and the Woollen and Worsted industries have already established Associations, while the Memorandum and Articles of Association of a number of others are approaching completion.

The movement towards the formation of Research Associations is very encouraging, but naturally it is not yet sufficiently advanced to enable knowledge to be communicated from industry to industry. A start has, however, been made at co ordinating the means of distributing information amongst a number of closely related but separate industries by the award of a grant from the Department to the Textile Institute. This Institute has undertaken the duty of abstracting and indexing Scientific literature having a bearing on the textile trades, and it is understood that the various Textile Research Associations which are being established intend to combine in supporting the Textile Institute in this very important task.

The financial arrangements of two Research Associations call for special mention. The Iron Manufacturers' Research Association has subscribed the whole of the funds necessary without asking for any direct Government grants. By forming an approved Research Association, however, its members derive indirect financial benefit, through their subscriptions being regarded by the Inland Revenue Authorities as "business costs."

On the other hand, the Department has guaranteed a total expenditure by the Scientific Instrument Research Association of not more than £40,000 during the next five years on condition that the members of the Association make a contribution of £4000 from their net revenue during the same period and make no claim for any remission of taxation. This step has been taken because this group of industries falls into a class of "key" industries, and is in urgent need of research on a large scale. The negotiations of the Department with large groups of manufacturers have led to several important conclusions:—

(a) It is only possible to secure co-operation amongst firms which are conscious of the existence of a number of unsolved problems of common interest either to all or to a majority of them. Thus, the attempt to combine in a Research Association the makers of all types of internal combustion engines was not successful, although it was agreed that research as a co-operative basis is necessary. Similarly the movement for forming a Research Association, including both makers and users of refractories has made slow progress.

In each case, however, it is probable that separate Associations representing sections of each of these branches of industry will be formed, and that the various sections will unite for joint action on matters of common interest.

(b) It has been found that while highly localised industries, such as the Cotton trade, or comparatively small industries, such as Photography or Scientific Instrument making, are capable of organisation into Research Associations with little administrative difficulty, there are many others, such as the Woollen and Worsted industry and the Linen industry, which are so widely distributed that local Committees are needed in order to focus local interest and to secure local initiative in the concentration of effort towards a single administrative control.

(c) There is abundant evidence of the increasing realisation of the need for organised research in connection with industry, and it is certain that the movement towards this will receive a serious set back if the supply of research workers cannot be expanded in proportion to the increasing demands. The Report therefore again contains a grave warning of this danger, and states that the Department regards the expenditure as grants to students and to othe

research workers as being of the first importance. It points out, however, that the responsibility for recruiting the army of research workers lies upon the Educational Authorities of the country, and quotes with hearty agreement the conclusion arrived at by the Committee appointed to inquire into the position of Natural Science in the Educational System of Great Britain.

Arrangements have been made for the co-ordination of the work of the Research Department with that of the Standing Joint Industrial Councils which are being established as a result of the Whitley Report, an agreement having been made that the Department will consult the Joint Industrial Council of an industry, where one exists, before setting up a Research Association for that industry.

During the year under review the Department has become responsible for the maintenance of the National Physical Laboratory, but since practically all the work done in this Institution is for a few purposes, it cannot be described in the report.

Progress has been made with the work of the Fuel Research Board, which published a special report in the course of the year, of the Tin and Tungsten Board, and of the Committee dealing with research on Mine Rescue Apparatus, on Timber, and on Building Materials.

In view of the pressing importance of the problems of the cold storage of food, a Food Investigation Board has been set up, and much useful work has been done both on the preservation and on the methods of preparing food.

One of the most interesting developments during the year has been the formation, with the help of the Medical Research Committee, of an Industrial Fatigue Research Board, whose function is to consider and investigate the relations of the hours of labour and other conditions of employment, including methods of work, to the production of industrial fatigue, having regard both to industrial efficiency and to the preservation of health amongst the workers.

Systematic surveys of the fields of research are being made in various directions, surveys having been undertaken on the sources and methods of obtaining Zinc, on Lubricants, and on Illuminating Engineering.

It is of interest to note that organised research is being developed in the Overseas Dominions and in the United States of America. The Report contains summaries of the schemes that are being drawn up in these countries.

The second part of the Report deals with researches initiated by professional and Scientific Societies assisted by grants by the Department. These are not described in detail, but reference is made to the work on the Deterioration of Harbour Structures, on the Fire Resisting properties of Concrete, on the Disintegration of Salts, on the Acoustics of the Pianoforte, and on Insulating Materials.

Special mention is made of the successful issue of the research carried on at Stoke-on-Trent with the object of making Hard Porcelain from British Materials. The problem has been solved at little more than half the cost anticipated, and it is probable that the porcelain will be on the market very shortly.

The Report ends by describing the method of awarding grants to students and research workers.

The Theory of Solution.—Given that molecular and atomic reactions can be accompanied by approximately close proportional interchanges in the heat of reaction and solution of bodies, I would point out that something might be ascribed to a theory of solution in which the accompaniment of either a gain or loss of heat with such atomic or molecular equivalence would represent hydrolytic action of water mechanically causing solution in which the interchange of ions is taking place.—J. C. Thomlinson, B.Sc.

ORDER OF MINISTRY OF MUNITIONS.

Chlorine and Chlorine Compounds.

The Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm Regulations, and of all other powers enabling him, hereby orders as follows:—

1. For all purposes of this Order, "chlorine" shall mean elementary chlorine, either in gaseous or in liquid form, and "chlorine compound" shall mean and include bleaching powder, sodium hypochlorite, all descriptions of chlorine bleach liquor, and all other compounds of or products containing chlorine which are commonly manufactured direct from chlorine, whether in gaseous or in liquid form. And for the purposes of Clauses 2, 4, and 5 of this Order, the weight of any chlorine compound shall be deemed to be the weight of the chlorine contained in the same.

2. As on and from September 16, 1918, until further notice, no person shall produce or manufacture any chlorine or chlorine compounds in quantities exceeding in the aggregate one ton during any one calendar month except under a licence issued by or under the authority of the Minister of Munitions and in accordance with the terms and conditions of such licence as to the quantities to be manufactured or otherwise.

3. As from the date of this Order all persons producing or manufacturing chlorine or any chlorine compound, or engaged in any manufacture, trade, or business in which chlorine or any chlorine compound is used, shall carry out and comply with all instructions and directions which may be given by or on behalf of the Minister of Munitions with a view to avoiding loss or waste of chlorine.

4. As on and from September 16, 1918, no person producing or manufacturing chlorine or any chlorine compound shall, except under and in accordance with the terms and conditions of a licence issued by or under the authority of the Minister of Munitions, use more than one ton in all of such chlorine or any chlorine compounds during any one calendar month for the purposes of all other manufactures, trades, and businesses carried on by him.

5. As on and from September 16, 1918, no person shall supply chlorine or any chlorine compound to any person (whether in pursuance of a contract existing at the date of this Order or otherwise), except under and in accordance with the terms and conditions of a licence issued by or under the authority of the Minister of Munitions. Provided that no licence shall be required by any person to supply not more than 56 lbs. of chlorine or chlorine compounds to any one person during any one calendar month.

6. As on and from the day following the date of this Order, no person shall sell or purchase or offer to sell or purchase any liquid chlorine or bleaching powder at a price exceeding the maximum price specified for the same in the schedule hereto specified for the same in the schedule hereto. Provided that such maximum prices shall not apply to—(a) any sale of liquid chlorine or bleaching powder for export from the United Kingdom to any country other than the Channel Islands or the Isle of Man; nor (b) any sale of less than 56 lbs. of liquid chlorine or less than one ton of bleaching powder.

7. All persons engaged in producing, manufacturing, selling, distributing, or storing chlorine or any chlorine compound, or in any manufacture, trade, or business in which chlorine or any chlorine compound is used, shall make such returns with regard to their business, and shall verify the same in such manner (including production of their books to any accredited representative of the Minister of Munitions being a chartered or incorporated accountant) as shall from time to time be required by or under the authority of the Minister of Munitions. And in particular all such persons shall, within fourteen days from October 1, 1918, make to the Minister of Munitions returns of all stocks of chlorine and chlorine compounds

in their possession or under their control on that date, such returns to be sent to the Department of Explosives Supply, Storey's Gate, Westminster, S.W. 1, and to be verified and authenticated by the signature of the person making the same, or, where such person is a firm or company, of a partner, director, or other responsible officer. Provided that no return shall be required from any person whose stock of chlorine and chlorine compounds on October 1, 1918, does not exceed in the aggregate 1000 lbs.

8. This Order may be cited as the Chlorine and Chlorine Compounds Order, 1918.

NOTE.—All applications in reference to this Order, including applications for licences, should be addressed to the Department of Explosives Supply, Storey's Gate, Westminster, S.W. 1, and marked "Chlorine control."

Maximum Prices.

Liquid chlorine..	6d. per lb.
Bleaching powder	£15 per ton

The above maximum prices are net cash prices for liquid chlorine and bleaching powder delivered free on rail or into cart or vessel at maker's works, and include the cost of filling into packages (cylinders and casks), but not the cost of the packages themselves. The packages, if supplied by the maker or vendor, may be charged for in addition at not exceeding current market prices, subject to refund in full on return of the same, carriage paid and in good condition, to the maker's works, except that a reasonable hire charge may be made for packages returned after the expiration of any reasonable period stipulated for the return of the same.

Where credit is given to the purchaser a reasonable extra charge may be made, provided that the discount allowed for net cash is quoted on the invoice or in the contract for sale, and is such as to bring the net cash price withing the maximum authorised.

Where delivery is made elsewhere than at maker's works all costs of transport from maker's works to place of delivery may be charged in addition, any cartage or haulage to be charged at not exceeding local rates.

MEXICAN NEWS.*

Decree Regarding Exportation of Metals.

ON March 22 President Carranza, by virtue of the powers granted him by the National Congress, issued the following decree, which went into force at once and is now in full effect:—

Article 1.—The exportation of bars of silver, or of gold and silver mixed, is prohibited except by special permission in each case from the Secretary of the Treasury.

Article 2.—For the exportation of ores and concentrates that contain gold and silver, the laws of September 27 last will be rigidly enforced.

Article 3.—The exportation of gold bars, gold money, either of the country or foreign, and silver money is strictly prohibited.

Article 4.—By previous arrangement with the Secretary of the Treasury permission for the exportation of silver pesos may be obtained if at the same time a quantity of gold metal of equal commercial value with the peso be imported for coinage in the mint.

Article 5.—The Monetary Commission, in conformity with the Secretary of the Treasury, will acquire the bars of gold and silver that it believes necessary for its conservation or coinage in the mint.

Article 6.—The importation of gold in bars and gold money, foreign or national, will be free from all consular duties.

* Bulletin Service of the Mexican News Bureau.

To Gather Crop Statistics.

The National Chamber of Commerce has sent circulars to all the subsidiary organisations of that character throughout the Republic, asking them to send in promptly complete statistics covering the area and probable yield of various crops. By this means it is hoped to be able to arrange in advance for the shipment of surplus products in one section to others where there is a lack from whatever cause. In the past there has been great difficulty on this account. Because of lack of previous arrangement shortage of crops has caused suffering in some sections, while in others there was a plethora. This will be avoided in the future as far as possible. Already it is announced that the coming crops in most districts will be greater than ever before.

PROCEEDINGS OF SOCIETIES.

FARADAY SOCIETY.

Ordinary Meeting, July 23, 1918.

Sir ROBERT HADFIELD, Bart., F.R.S., President, in the Chair.

MR. JOHN G. A. RHODIN read a paper entitled '*Contributions to the Chemistry of Aluminium and Aluminium Alloys.*"

The paper dealt with the sorting of various kinds of scrap according to percentage of aluminium by means of direct determination of aluminium, soluble in 10 per cent NaOH. The method was described in detail, and it was claimed for it that it allowed oxide to be determined as well. Certain phenomena relating to the behaviour of aluminium powder, when heated in air, were discussed, and also the preparation of Al_3O_4. A curve of specific gravities corresponding to percentages of aluminium in various alloys was given. Determination of specific heats was mentioned as an alternative.

Dr. W. ROSENHAIN, F.R.S., said the presence of oxide in aluminium was of first-rate importance in substances like aluminium powder. Of two samples that looked alike, one might contain 20 to 30 per cent of oxide. The appearance of the fractures in the samples shown suggested enclosures of foreign material rather than that the oxide was dissolved in the aluminium. He suggested the determination of melting-points as an alternative line of attack.

Mr. CLAUDE T. J. VAUTIN submitted a new form of alumina, perfectly black finely-divided powder, containing 70 per cent alumina and a small percentage of hydrate, which confirmed the author's statement as to the reduction of Al_2O_3 to a lower oxide. On the application to this of a match, two distinct reactions were visible. An initial dull glow indicated the reduction of the Al_2O_3 to what he believed was Al_2O; this was at once oxidised by the air, and a bright glow spread through the mass.

Dr. R. SELIGMAN found it difficult to accept the statement that caustic soda would dissolve the aluminium and leave undissolved the alumina supposed to be dissolved in that aluminium.

Dr. A. E. P. GWYER supported Dr. Seligman's criticism.

Mr. A. J. CHAPMAN thought the author had achieved something towards obtaining a direct determination of aluminium.

Mr. C. N. WATERHOUSE suggested that the presence of the oxide considered by the author to be dissolved in aluminium might account for some of the contradictory results that had been obtained in experiments with aluminium and its alloys.

Sir ROBERT HADFIELD, F.R.S., hoped that the author's study would enable them to get rid of the imperfections

which were factors in preventing sound castings. He touched on the importance of aluminium to the steelmaker.

Mr. R. A. H. Gertin testified to the practical value of the methods of analysis described in the paper.

Mr. Robert J. Anderson (Cleveland, U.S.A.) presented a paper entitled "*Metallography of Aluminium: Recrystallisation and Grain-growth—the Result of Deformation in the Cold prior to Annealing.*"

During the course of some recent tests on the recrystallisation in controlled aluminium sheet on annealing, some interesting recrystallisation and grain-growth phenomena were observed in the metal, which are confirmatory of the general laws of grain-growth and recrystallisation as now understood.

While the degree of strain is indefinite, the effects of temperature on deformed aluminium are recorded, and instances of differential grain-growth are presented. These results appear to show definitely that aluminium is similar to other metals as regards annealing laws. Very many important and interesting, to say nothing of speculative, consequences arise from a consideration of recrystallisation phenomena, and this branch of metallography is still to be thoroughly investigated.

Prof. H. J. M. Creighton (Swarthmore College, U.S.A.) presented a paper on "*Reinforced Concrete* v. *Salt, Brine, and Sea-water.*"

On account of the rapidity and cheapness of construction, at present attention is focused on the reinforced concrete ship. The durability of this is still an undetermined factor, but in a large measure it will depend upon the action of the sea-water on the concrete and on the iron reinforcements.

The following conclusions are drawn by the writer from his investigations of the action of salt, brine, and sea-water on reinforced concrete:—

1. All concrete which is not waterproofed is more or less porous to water and brine.

2. Brine readily softens the surface of concrete, and therefore more easily penetrates to the reinforcements, on which it exerts a distintegrating action, that owing to the attendant expansion gradually weakens the concrete, causing it to crack and split, and in some cases to fall away from the reinforcements.

3. The more porous the concrete, the more rapid the disintegration of reinforcements.

4. Reinforced concrete floors which come in contact with brine will gradually develop leaks. These will be followed by incrustations of discoloured salt on the underside, where, later, iron-stained hair cracks will develop, running parallel to the reinforcements. As the deterioration progresses the cracks will widen, and owing to the great expansive force of the accumulating iron oxide, the concrete will be gradually pushed from the corroded reinforcements and ultimately fail.

In view of the foregoing conclusions it is evident that reinforced concrete immersed in brine or sea-water is liable to subtle and persistent deterioration, due to electrolytic action between the salt and the reinforcements. Therefore the permanence and durability of reinforced concrete ships is a matter of considerable doubt, unless the sea-water is prevented from coming in contact with the reinforcements. Such prevention may be effected by coating the reinforcements with protective paint, or by applying to the outer surface of the concrete some material which will render it waterproof. Since most of the substances which have been used for this purpose give results which are far from satisfactory, the writer suggests that good results might be obtained by coating the concrete with a very thin layer of a suitable metal by means of the Schoop Metal Spraying Process. Finally, concrete that is to be used in the construction of ships should undoubtedly be made from cement of fine pulverisation, low in alumina and high in silica, free as possible from gypsum, absolutely free from lime, slow in setting, and quick in hardening.

Mr. C. H. Desch, in a written communication, emphasised the importance of the quality of the concrete as a factor in resisting destruction by sea-water. The rapid destruction recorded in America was quite exceptional in this country. In a well-mixed concrete of low permeability the reinforcement was well protected. The salts in sea-water reacted with the outer layers of concrete, but the products were dense and prevented further penetration. He hoped experiments would be made on the application of the Schoop process.

NOTICES OF BOOKS.

Cellulose, an Outline of the Chemistry of the Structural Elements of Plants, with Reference to their Natural History and Industrial Uses. By Cross and Bevan. New Impression, with a Supplement. London, New York, Bombay, Calcutta, and Madras: Longmans, Green, and Co. 1918. Pp. xvii+348. Price 14s. net.

This monograph on the properties, nature, and uses of cellulose is well known and highly valued by workers in this region, many of whom have embarked upon researches suggested by the authors. In the new edition the progress of twenty years was described, including fresh methods of experimenting and new classes of derivatives, and this fresh impression of the latest edition contains a supplementary chapter bringing the information down to the latest possible date. The authors' recent work has led them to the conviction that cellulose is to be regarded as an extremely sensitive and labile substance, readily modified by any reagent, even water. They suggest that a standard process of purification should be adopted in order to get a "normal" product, and they emphasise the need for a thorough revision of empirical standards. In the supplementary chapter short summaries are given of recent work, and allusion is made to the enormous development of the cellulose industry and the need for much investigational work on the subject. The authors, regarding cellulose as the prototype of colloidal matter, point out that the exhaustive study of the substance and its derivatives will provide material for generalisations yet to be made as to the nature of colloids, and the book abounds in suggestions for profitable research work.

Lecithin and Allied Substances. The Lipins. By Hugh Maclean, M D., D.Sc. London, New York, Bombay, Calcutta, and Madras: Longmans, Green, and Co. 1918. Pp. vi+206. Price 7s. 6d. net.

The chemistry of lecithin and allied substances is in a sufficiently advanced state to warrant the publication of a monograph on the subject, and no better author could have been found than Dr. Maclean, whose work on the subject has been instrumental in bringing about progress of the utmost importance. He is responsible for having definitely proved that the so called lecithin of the older authors is actually a mixture of two substances, true lecithin and kephaline, and his work on methods of separation of these two is fully described, though not by any means to the exclusion of that of other investigators. The attempts, hitherto unsuccessful, which have been made to synthesise lecithin are discussed, and a very full account is given of the properties of the substance. Kephaline, sphingomyelin, and cuorin are similarly treated, the occurrence of the substances and methods of extracting and purifying them being described in detail. A careful analysis is given of the work which has been done on "protagon," and its complexity is definitely established. The little that is known of the nature of the lipins is shortly discussed, their function being admitted to be quite unknown. The monograph is the most complete and authoritative on the subject in English, and the author is to be heartily congratulated upon his successful piece of work.

Chemistry for Beginners. By C. T. KINGZETT, F.I.C., F.C.S. Third Edition. London: Baillière, Tindall, and Cox. 1918. Price 2s. 6d. net.

THE new part of the third edition of this book consists of some 60 pages devoted to descriptions of practical work which can be performed to illustrate the text of the theoretical part. The author has not attempted to outline a definite course of practical work, but has arranged this part of the book alphabetically under the headings of different pieces of apparatus and appliances, of which illustrations are supplied, together with notes concerning their uses in the laboratory. This arrangement will probably suit teachers who merely require notes and hints about different experiments, but students would probably find a course of work graduated in difficulty and illustrating the text more useful.

Plant Products and Chemical Fertilisers. By S. HOARE COLLINS, M.Sc., F.I.C. London: Baillière, Tindall, and Cox. 1918. Pp. xvi+236. Price 7s. 6d. net.

THIS book is the first volume of a series of works on industrial chemistry written by various authorities and edited by Dr. Samuel Rideal. The series aims at treating applied chemistry from the chemical rather than the engineering standpoint, and the books are to be regarded as guides to standard literature to be used in conjunction with and not instead of current text-books. A comprehensive survey is given in this first volume of the application of science to agriculture, and agricultural students as well as practical farmers have every reason to be grateful to the author for providing them with a thoroughly interesting handbook of an unusual type. The different classes of fertilisers are first considered, the various products being followed from factory to field and back to factory again. A short account is given of the properties and uses of different manurial substances in turn, all kinds of industrial by-products being discussed. Then sections on the soil treat of the characteristics of soils and methods of increasing their productivity. In the third part of the book the author passes to the consideration of the substances elaborated by crops, giving a useful table showing the nature of such substances and their feeding value. Finally, in the last part the production of meat and dairy products is treated, some account being given of the different foods fed to beasts and the process of digestion. An interesting short discussion of the future of agriculture and questions of labour and education bring the book to an end. The author's experience of agricultural problems, both in England and India, enable him to draw his illustrations from diverse sources, and the book is a useful contribution to the literature of scientific agriculture.

Sir William Ramsay. By TARINI CHARAN CHAUDHURI, M.A. London, Calcutta, Winnipeg, and Sydney: Butterworth and Co. 1918. Pp. ix+66. Price 1s. 8d. net.

THIS short biographical sketch of the life and work of Sir William Ramsay has evidently been written by an admirer who could form an accurate estimate of the value of his contributions to knowledge, as well as his powerful and invigorating influence over his pupils. There can be no doubt that the historical method of teaching science stimulates the interest of students and gives them a valuable insight into the methods of the great discoverers, and busy teachers, especially those who are working in Indian colleges, may find this short biography useful either for their own reading or to give to their students. Ramsay's early work in organic chemistry, followed by his researches on the gases of the atmosphere and finally his experiments in radiography, are outlined, and a clear view is given of the spirit of research which animated all his work.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

NOTE.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxvi., No. 17, April 29, 1918.

Balance of some Constituent Principles of the Sugar-beet during the Manufacture of Sugar.—Emile Saillard.—The various products which are obtained during the manufacture of sugar have been subjected to analysis for dry matter, nitrogen, potash, soda, and phosphoric acid, and thus the balance sheets of these substances at different stages have been drawn up. It is thus found that practically all the potash, soda, and phosphoric acid can be recovered and returned to the soil, but, on the other hand, about 50 per cent of the total nitrogen is lost.

No. 18, May 6, 1918.

Influence of Cadmium on the Properties of Alloys of Copper and Zinc.—Léon Guillet.—Cadmium has no influence upon the mechanical properties of brasses containing 60 to 70 per cent of copper unless 1 per cent of cadmium is present. It then causes a lowering of the resilience. When 2 per cent of cadmium is present it separates out in round granules. Commercial zinc does not usually contain as much as 1 per cent of cadmium, and hence there is no need to take account of this metal in industrial operations.

No. 19, May 13, 1918.

Neutral Nitrate of Zirconyl.—Ed. Chauvenet and L. Nicolle.—It has been stated that the neutral nitrate of zirconium can be prepared by evaporating *in vacuo* a nitric acid solution of zirconium hydrate, but the authors have not succeeded in obtaining the substance even when evaporation of the very concentrated solution was carried on at a low temperature in a current of carbon dioxide charged with nitric vapours. They conclude that the nitrate does not exist. The crystalline product obtained was always the dihydrated neutral nitrate of zirconyl, $Zr{<}^{O}_{(NO_3)_2}.2H_2O$. Attempts to dehydrate this substance by heating to as low a temperature as possible in a current of CO_2 containing nitric vapours were always unsuccessful, for the nitrate always gave off nitric acid. Another hydrated nitrate containing 3·5 molecules of water can be prepared. It is formed at 0°, and is stable only up to 10°, above which temperature it rapidly gives the dihydrate.

No. 20, May 21, 1918.

Ferro-silicons not attacked by Acids.—Camille Matignon.—The resistance to acids of six different ferro-silicons and one ferro-boron was investigated, and it was found that the latter cannot be compared in this respect with the ferro-silicons. The introduction of small quantities of nickel increases the chemical resistance of the alloy. The acids used were nitric acid of different strengths and mixtures of acetic and butyric acids. None of the alloys resisted the action of hydrochloric acid.

Basic Nitrates of Zirconyl.—Ed. Chauvenet and L. Nicolle.—The normal hydrate of zirconyl nitrate, $Zr{<}^{O}_{(NO_3)_2}.2H_2O$, is very soluble in water, and solution is immediately followed by hydrolysis. When heated to about 120° it gives the basic nitrate, $\left[Zr{<}^{O}_{(NO_3)_2}\right]_3.ZrO_2.7H_2O$, while at higher temperatures hydrated compounds are obtained which are more and more basic.

MISCELLANEOUS

Linseed Oil and Fatty Acids.—When the glycerin is removed, these acids, after a preliminary heating not above 100° C. and keeping set to a dubbin, will give a suitable polish to leather.—J. C. THOMLINSON, B.Sc.

City of London College, White Street, Moorfields, E.C.—The new Session will begin on Monday, September 30. A comprehensive programme of commercial subjects has been arranged. New students will be enrolled on Thursday, September 26, from 6 to 8.30 p.m., when an Address will be delivered by Alderman Sir George Wyatt Truscott, Bart. At the recent examinations for prizes in foreign languages conducted by the London County Council, Mrs. E. M. Goult, a student of the College, was awarded the "Credito Italiano" prize of £50 for Italian.

The Wet Thiogen Process for Recovering Sulphur from Sulphur Dioxide in Smelter Gases.—*Bulletin* No. 133 of the Bureau of Mines contains an account of a critical study of the wet thiogen sulphur recovery process conducted by Mr. A. E. Wells. The process is based upon the fact that a solution of sulphur dioxide reacts as follows with an alkaline earth sulphide either in finely-divided water suspension or in solution:—$2BaS+3SO_2=2BaSO_3+3S$. The investigation of the process shows that every step can be controlled and successfully carried out on a small scale, and in some localities at any rate the process could be profitably used on a commercial scale. The percentage of sulphur in the gases should be as high as possible and not less than 6 per cent; moreover, it should be fairly constant. The gas should be clean from dust and fume before it is absorbed, and the temperature of the mother-liquor should be nearly the same as that of the surrounding atmosphere. The cost of absorption would depend to a certain extent upon the average temperature of the air. The operations involved are not more complicated than similar operations now carried on in standard commercial apparatus, but the conditions under which precipitation is performed must be under careful supervision.

Mineral Resources of Great Britain.—The Board of Agriculture and Fisheries desire to give notice of the publication of a second edition of Vol. V. of the "Special Reports on the Mineral Resources of Great Britain," which have been prepared by the Director of the Geological Survey in response to numerous enquiries that have arisen through the conditions brought about by the war. The following minerals are dealt with:—Potash-Felspar, Phosphate of Lime, Alum Shales, Plumbago or Graphite, Molybdenite, Chromite, Talc and Steatite (Soapstone, Soap Rock, and Potstone), Diatomite. In the main it is a reprint of the first edition, which deals with the occurrences and workings, past and present, of the minerals specified in the title. Some additional information on potash-felspars, steatite, and diatomite has been inserted. Price 1s. Copies may be obtained through any book seller from Messrs. T. Fisher Unwin, Ltd., 1, Adelphi Terrace, London, W.C. 1, who are the sole wholesale agents to the trade outside the County of London; or from the Director General, Ordnance Survey Office, Southampton.

NOTES AND QUERIES.

_ Our Notes and Queries column was opened for the purpose of giving and obtaining information likely to be of use to our readers generally. We cannot undertake to let this column be the means of transmitting merely private information, or such trade notices as should legitimately come in the advertisement columns.

Alcohol from Potatoes.—Can anyone tell me how alcohol is obtained from the potato? Also, what is the spirit, &c., which is extracted from the horse-chestnut, and how is it extracted?—STIMECH.

Emery Grit, Silicates, and Magnesium Salts.—We have an enquiry for emery grit, silicate powder, and magnesium chloride, and shall be glad to know whether among your advertisers any firm is in a position to handle such an enquiry. If so, the favour of their address will greatly oblige.—ARNHOLD, KARBERG, and Co, 14, Fenchurch Street, London, E.C 3.

TO comply with Regulation 8 B of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Assistant Librarian required for the Library of Nobel's Explosives Company, Scotland. Applicants may be either male or female, and must hold a University Degree in Science. —Applications, giving full details as to training, age, &c., to be addressed to "Manager," care of Wm. Porteous and Co., 9, Royal Exchange Place, Glasgow.

An experienced Metallurgical Chemist required for the Laboratory of a large Steel Work. Give full particulars as to training and experience, age, and salary required. —Address, "Steel," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

ANALYTICAL LABORATORY.—Assistants wanted; must be conversant with Volumetric Work and preferably have knowledge of Pharmacy. £90 to £130.—Address, Box 661, Smith's Agency, Ltd., 100, Fleet Street, E.C. 4.

Chemist, invalided from the Army, seeks engagement, preferably in the south of England. Experience in manufacture of Heavy Chemicals and Organic Products. Speciality the Rare Metals and their compounds.—Address, D. G., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist, twenty-seven years' experience in Iron and Steel Works' Analysis, requires Post. Aged 44.—Address, William Graham, 34, Cimla Road, Neath, Glamorganshire.

CHEMISTRY TUTOR required to Lecture and take charge of Laboratory at large Teaching Institution in London, preparing mainly for London University Examinations. He must be a High Honourman with teaching experience. Commencing salary £240 per annum.—Apply, in first instance, to "Chemistry," care of U.B.C., 48, Southampton Row, W.C. 1.

LABORATORY. — Assistants wanted for Chemical and Pharmaceutical work. Must have had some Chemical and good Pharmaceutical experience. Ineligible; unqualified. Salary, £100 per annum.—Apply, Box No. 627, Smith's Advertising Agency, Ltd., 100, Fleet Street, E.C. 4.

Research Chemists wanted, with good knowledge of Physical and Electro chemistry. Salary, £200 to £350 according to qualifications and experience.—Apply to the Salt Union, Ltd., Weston Point, Runcorn.

Works Analytical Chemist required. One conversant with Soap Manufacture, Nicotine Extractions, and Agricultural and Horticultural Preparations. State full particulars and salary required.—Address, W. A., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

ANALYTICAL BALANCE wanted, Sartorius preferred.—Address, JOHN HALL and SONS, Ltd., Broadmead, Bristol.

UNIVERSITY OF LONDON.

ST. BARTHOLOMEW'S HOSPITAL AND COLLEGE.

A DEMONSTRATOR IN CHEMISTRY, Man or Woman, is required for the above Hospital. Salary £200. Particulars of the appointment may be obtained from the Dean of the Medical School.

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DEFINITION OF VALENCY.

By F. H. LORING.

THE atoms of different elements, or the atoms of the same elements, chemically unite with one another to form bodies of varying stability against decomposition by heat, exception being made (1) to the inactive gases which do not combine at all, and (2) to certain atoms lacking in mutual affinity, or being too mutually unstable to co-exist at ordinary temperatures as definite molecular compounds. In respect of (2) fluorine and oxygen would be good examples, since no compounds of these two elements solely have been produced. Fluorine unites more or less vigorously with every element except oxygen, chlorine, nitrogen, and, of course, those of the helium family.

The atoms which do combine, combine to form groups known as molecules. (The term *group* is herein used to denote atomic combinations involving two or more atoms). In solids it cannot be assumed that the groups are definitely defined as is the case with regard to gases. The selective property asserts itself more diffusely in solids than in gases, so that the latter afford numerous examples in which the affinities are not fully satisfied; whereas, in the former, the affinities may be more scattered and, indeed, generally fully satisfied; consequently, this action may help to bind the ideal groups or molecules together as a whole. "Even when . . . the combining possibilities of an atom are exhausted, it possesses a particular kind of affinity, which enables it to form molecular complexes." In other words, molecules are known to associate.

Molecules which, for example, are normally diatomic at ordinary temperatures may become monatomic at high temperatures, permanent combination being then prevented owing to the extreme activity of the gas-particles; Br_2 and I_2 may be taken as examples. The gas-molecules are, however, definite entities (the most direct proof of the existence of atoms and molecules is to be found in Sir J. J. Thomson's positive ray experiments), and by determining the combining proportions of respective atoms in bulk, and the density of the resulting substance in the vapour state, it has become possible to assign to the atoms the property of selecting or receiving to themselves certain numbers of other atoms, but this selective or receptive power or capacity does not represent an attractive force or affinity which corresponds in magnitude to the number of atoms attracted or united. For example, a man may have two hands and be able to select two objects or have the power of joining hands with two other men of one hand each, or he may join hands with one man with two hands. The two handed man, in fact, has a selecting capacity of *two*, but his affinity or hand-gripping power depends upon an energy consideration which depends upon the other man's grip as well, so that the stability or strength of union is independent of the number of hands. The number of hands, however, represents the valence or valency.

The hand illustration of valency is an exceedingly useful one, and there are cases which point to the possibility of the valencies, under certain conditions, being self-satisfied, as if, for example, the two-handed man had interlocked his own hands, thus by analogy implying that two valencies of the atom are rendered inactive towards other atoms.

Some atoms combine individually with eight other atoms (*e.g.*, osmium fluoride, OsF_8), as if the atom had *eight* hands, to continue the simile, this being the maximum valency, whilst *one* is the minimum in other cases. Many atoms appear to bring into requisition more hands, as it were, when combining with the atoms of one particular kind of elementary substance as distinct from another, so that such atoms exercise a *variable* valency. It might appear that the reserve valencies implied in the foregoing statement are internally- or self-satisfied, as stated above, until called into action, but much uncertainty prevails regarding such matters. Some atoms have apparently only one unit valency and answer to the one-handed man. The inactive gases answer to a man without any hands at all, unless it be assumed that certain valencies are internally satisfied and that they cannot be called into action.

It should be noted that the one-handed man, or the man without any free hands at all, could, when closely associated with other men, exercise certain interlocking powers if the legs were brought into proper action for this purpose. Hydrogen, for example, which is supposed to be only univalent in the solid state (as in other states) may exercise certain subsidiary affinities or interlocking powers which might account for its cohesion. Frozen liquid hydrogen is a rigid substance like frozen water, and if the affinities are to some extent diffuse in the latter (see below) it would be expected that they would be diffuse in the former. This means that the unity valency values may not represent a complete statement of fact when taken as implying that the valency is fully satisfied in the molecule, otherwise molecules of hydrogen, to keep to the one example, would behave like dust below the freezing temperature of this element; *but*, cohesion and valency are not generally regarded as the same phenomenon, and it is going beyond the doctrine of valency to discuss such matters. Before leaving this extension of the subject a few further observations may be of suggestive interest.

The inactive gases are liquefiable and solidifiable, and in these states they behave in a general way like ordinary liquids and solids, but they do not form chemical compounds with other elements, and it is doubtful whether they feebly combine or associate amongst themselves to form molecular complexes even of the simplest type. For instance, the atoms of liquid argon do not appear to associate. The fact that they have no valency does not mean that they have no affinities at all, otherwise there would be no cohesion. Water and hydrogen afford parallel examples to the above in some respects, as H_2O and H_2 may be regarded as molecules practically of zero valency, yet molecular complexes or association phenomenon in respect of the former are known.

Radio-active phenomena indicate that possibly helium is a common constituent of all atoms except hydrogen, in which case its combination must be of a superior order to anything coming within the range of controllable pheno

menon known as chemical action, but like the molecule in crystals (see below) the definite individuality of such a fundamental helium atom or unit taken as a sub-atom may be lost, or merged into a larger whole. In this case a deep-seated type of valency may exist accompanied with an affinity far superior to anything exhibited in chemical phenomena, just as ordinary valency is in a sense more fundamental and definite than that which is connected with the formation of molecular complexes. The gradation is fairly complete as the last-named phenomenon shades off into cohesion. It will be seen that this line of reasoning leads to four physico-chemical steps, namely :—

1. Helium atoms as sub-atomic units, involving a superior type of valency and affinity. A further sub-division into similar hydrogen units has been foreshadowed as a possibility, in which case a similar antecedent step to this one might be expected.
2. Atomic combinations under control of the chemist, involving ordinary valency, but with affinities which are not co-related to the valency values.
3. Molecular complexes, involving a sort of residual or excess valency which tends to become diffuse.
4. Cohesion, involving a still more remote type of valency which being wholly diffuse is more of the nature of an affinity pure and simple, and, indeed, in this case the idea of *valency* may be entirely eliminated.

It must be admitted that these statements are to some extent speculative, but such ideas, though of necessity very general, may help to clear up doubtful points which obscure the interpretation of valency proper. The quotations given at the conclusion of this article may be of interest in this connection.

As stated above, the valencies exercised in solids are largely conjecture, but there is sufficient evidence in many cases to show that the values assigned to the atoms represent characteristic properties. For instance, hydrogen and oxygen combine to form water in the atomic proportion $n(HH):nO$, and in the gaseous state the molecule H_2O is known. Oxygen in this case is said to be divalent (or bivalent) and hydrogen univalent (or monovalent). In the liquid or solid states molecular complexes are said to be formed, these being represented as $(H_2O)n$. Probably in such cases the valencies are to some extent diffuse, but uncertainty exists with regard to the precise disposition of the valencies when considering the manner or direction in which they may be supposed to operate. In solids the valencies may extend to atoms of adjoining "molecules," so that definite molecules in solids are considered by some as purely an ideal concept, their existence becoming definite, however, when, by the application of heat, the kinetic energy imported to the atoms causes them to move about in groups. When the heat is intense enough the groups themselves break up into single atoms.

In crystals, X-ray analysis has shown that the constitutional formulæ of the chemist do not exist as such, the molecular individuality then being more or less lost, and this agrees with the foregoing statement with regard to solids in general.

The degree of stability of a compound depends upon its composition or character apart from the valencies of its respective atoms. It sometimes happens that particularly stable compounds have other than the normal valencies exercised in the molecule; or, on the other hand, the normal valencies are not fully satisfied. Nitric oxide, NO, is particularly stable at moderately high temperatures, and it seems probable that both nitrogen and oxygen are quadrivalent (or tetravalent) in this case. It might be supposed that the strength of the atomic union, *i.e.*, the resistance of the compound to decomposition when its temperature is raised, may be due to the number of valencies exercised, and therefore a connection between valence and degree of affinity at once suggests itself; but there are so many exceptions in this respect that no law has been established.

It will be seen that valency on the whole is a somewhat elastic conception. When an atom is defined as having a certain maximum valency, the value so assigned to the atom is only characteristic when entering into combination with certain other atoms. Similarly, the minimum valency is only characteristic in respect of other particular combinations. Some atoms have no variable valency, in which case the maximum valency and minimum valency coincide. There are, however, combining regularities which are sufficiently well-defined to enable one to classify the elements into groups and at the same time to assign to their respective atoms certain valency values, so that combinations may be predicted and chemical behaviour elucidated.

The regularities of the valency values may be expressed in tabular form thus :—

	H.	He.	Li.	Be.	B.	C.	N.	O.	F.	
Max. val. ..	1	0	1	2	3	4	5	4	3	&c.
Min val. ..	1	0	1	2	3	4 ?	3	2	1	

The valency (or valence) of an atom is its selective or receptive capacity for one or more atoms (8 seem to be the limit) when combination takes place; and it is either expressed in terms of the *number* of hydrogen atoms (1 to 4) which it combines with or displaces, or in terms of the *number* of chlorine or fluorine atoms (1 to 8) which it combines with or displaces, under conditions that preclude the probability of each halogen atom itself functioning in a higher combining capacity than unity with respect to the atom whose valency is thus being defined.

There are cases in which the valency may be deduced by combinations involving other atoms than those cited as standards; but this definition affords a basis for establishing such other standards. For example, oxygen (O) usually functions as a divalent atom, but under certain circumstances it appears to be quadrivalent.

The following quotations bearing upon the subject under elucidation should be of particular interest :—

1. A. Smith, "Introduction to Inorganic Chemistry," 1918, 3rd. Ed.
2. Mellor, "Modern Inorganic Chemistry," 1912.
3. J. N. Friend, "Theory of Valency," 1909, 1st Ed.
4. J. Perrin, "Atoms" (translation), 1916.
5. *Science Abstracts*, Section A (Physics).

1. "It is only in the chemistry of carbon that the prejudice in favour of a single valence [4] still persists. All chemists admit that in carbon monoxide, CO, the carbon is bivalent. But not all chemists admit that it is also bivalent in fulminic acid, H-O—N=C, and in the isonitriles R-N=C. For the unsaturated compounds, like ethylene C_2H_4, and acetylene C_2H_2, all chemists write the formulæ $H_2=C=C=H_2$ and $H—C\equiv C-H$, although there is at present no experimental evidence that the formulæ $H_2=C—C=H_2$ and H—C—C—H, in which the carbon is trivalent and bivalent respectively, do not represent the fact equally well, so far at least as valence is concerned. When triphenylmethyl, $(C_6H_5)_3C$, was discovered by Gomberg it seemed as clear that in this substance one atom of carbon was trivalent as that the copper in CuI is univalent; but violent efforts were made to avoid this obvious conclusion. For example, it was suggested that three of the valences held one C_6H_5 group each, and that the fourth valence was divided amongst the three groups (partial valence). But valence goes by multiples of one equivalent, and this idea involved *splitting* one valence into thirds of an equivalent. The *affinity* of the carbon atoms is doubtless all divided amongst the three groups, so long as no fourth group is present to share it, for affinity is not divided into any definite number of units. This is a case of unconsciously confusing valence and affinity." (P. 137). (See "Theory of Valency," by Friend, p. 42).

"*Is Solution a Physical or a Chemical Change?*—These phenomena are, in part, accounted for by the fact that water is not a single substance, but a mixture. It is largely composed of dihydrol, $(H_2O)_2$, with much trihydrol, $(H_2O)_3$, near to 0°, and increasing quantities of monohydrol, H_2O, at higher temperatures. When *any* substance is dissolved in considerable amount of water the equilibrium amongst these three kinds of molecules is disturbed, and their proportions change:—

$$2(H_2O)_3 \rightleftarrows 3(H_2O)_2 \rightleftarrows 6H_2O.$$

Now, equal weights of these three kinds of water occupy different volumes, and hence solution is accompanied by changes in the volume of the *water*. The same condition in water explains the point of maximum density (4°). The change from $(H_2O)_3$ to $(H_2O)_2$ which proceeds as the temperature rises from 0° to 4°, is accompanied by a *shrinkage*, because the dihydrol has the higher specific gravity. Beyond 4° the usual expansion with rising of temperature prevails. . . . *Dissolving in water is* therefore partly a chemical and only partly a physical process—a part of the water is always affected, and a part or all of the solute may go into combination." (P. 202).

2. "The principle of self saturation breaks down when applied to the nitrogen oxides, say, $N^{III}O^{II}$. The relative density of the gas (Avogadro's hypothesis) will not let us write N_2O_2; that is, O=N—N=O. We are therefore confronted with what appears to be an odd unsaturated valency in the molecule, —N=O. Again, molybdenum forms a series of compounds with univalent chlorine or fluorine, $MoCl_2$, $MoCl_3$, $MoCl_4$, $MoCl_5$, and MoF_6, and vanadium forms VCl_2, VCl_3, VCl_4, and VCl_5. In view of facts like these it is difficult to maintain the thesis that the apparent inconsistency of the valency of an element is due to the mutual 'saturation' of pairs of valencies. Either a molecule can exist with free valencies, or Kekulé's maximum valency hypothesis breaks down when confronted with facts." (P. 71).

3. "In nitric oxide, NO, whose molecules are single at temperatures as low as −100° C., the valency of nitrogen evidently depends on that of oxygen. As we shall see in a later chapter, oxygen can function as a tetravalent atom, and in Chapter XIX. reasons are adduced to show that in nitric acid we have *the first example of tetravalent nitrogen* [—N≡O]. All efforts to obtain other derivatives of tetravalent nitrogen have, up to the present, resulted in failure." (P. 82).

4. "We have not yet put forward any suggestions as to the nature of the forces that keep the atoms grouped together within the molecule. It may be that each atom in the molecule *is joined to each of the others by an* attraction that varies according to their nature and decreases rapidly with the distance between them. But such a hypothesis leads to no verifiable conclusions and presents considerable difficulties. If all hydrogen atoms are attracted by all other hydrogen atoms, why is it that the only molecule built up of hydrogen atoms is H_2, the capacity of the hydrogen atom for combining with itself being exhausted directly two atoms become united? It appears as though each atom of hydrogen stretches out a single *hand* only. Directly this hand succeeds in gripping another hand the capacity for combination of the atom is exhausted; the hydrogen atom is therefore said to be *monovalent* (or better, univalent)." (P. 32).

5. "*Relation of Molecular Cohesion to Surface Tension and Gravitation.* . . . A. P. Mathews (*Journ. Phys. Chem.*, Oct., 1916, xx., 554).—This paper constitutes a revision and extension of the studies already made on molecular cohesion (*Abs.*, 1914, 279). Its contents are briefly as follows:—(1) A method of computing *a* of van der Waals' equation from the internal latent heat of vaporisation which seems to be free from all assumptions; (2) a proof that the values of *a* thus found are proportional to the two-thirds power of the product of the molecular weight and the number of valencies in the molecule; cohesion of a molecule depends, therefore, on the molecular weight and valency; (3) the cohesive attraction of two molecules at a unit distance apart is shown to be equal to the two-thirds power of their gravitational attraction at this distance, multiplied by the two-thirds power of the ratio of the number of valencies to the molecular weight; or, if M^2K, which is *a* for a single pair of molecules, is the cohesional attraction at a unit distance and m^2k the gravitational attraction of the two molecules at the same distance, then the following relation exists:—$M^2K = m^2k \times (\text{valencies/molecular weight})^{2/3}$. . . ." (P. 36, Jan., 1917).

"*Cohesion* II. H. Chatley (*Phys. Soc. Proc.*, Aug. 15, 1916, xxviii., 307). . . . The outstanding difference between chemical affinity and cohesion lies in the selective character of the first. So far as the ability of valency bonds of an atom to hold a molecule is concerned this is a common feature in organic compounds; what is distinct in the selective process is the feature of 'saturation.' The case of silica is considered. (1) In each submolecule, SiO_2, the four valency bonds of the silicon atom are linked in pairs to two oxygen atoms, this being purely chemical. (2) The sub-molecules are linked in pairs, if Nernst's formula $(SiO_2)_2$ is correct; this is chemical in so far as it occurs in constant proportions, but is cohesive in so far as it is the linkage of molecules as distinct from atoms. (3) The silica molecules are linked to one another irrespective of quantity, but with a configuration of maximum stability (crystal) with four axes (hexagonal system). Linkage can occur without geometrical form (amorphous solid). The magnitude of the linkage forces is inferior to that of (1) and (2), but not incomparably so (cohesion). (4) If gravitation is not a particular case of cohesion there is, in addition, a small mutual attraction with no vector quantity in accordance with Newton's law. It would seem possible to deduce from the fields about different stable systems of differently charged spheres some idea as to the feasibility or otherwise of explaining cohesion on these lines." (P. 452, 1916). In an earlier paper by the same author in the same society journal (Aug., 1915) it is stated that . . . "Kelvin was of opinion that cohesion could be explained by supposing the actual mass of substance to be concentrated into volumes quite small as compared with the whole volume. The density at such centres would be extremely high, and this intense density would, he thought, so increase the force of gravity between pairs of molecules very close together as to account for cohesion without necessitating any deviation from the inverse square law. . . . This [distance between molecules] is found to be of the order of 10^{-24} cm., much less than the reputed diameter of an electron *even! A second calculation is then made according to* an inverse law of undetermined index, the Newtonian constant for gravitation being still retained. This results in making the cohesive force vary as the inverse *sixth* power." (P. 586, 1915).

"*Results of Crystal Analysis*, IV. L. Vegard (*Phil. Mag.*, May, 1917, xxxiii., 395). . . . Hence, although it is found that the constitution of the solid state of zircon, rutile, and cassiterite should be ZrO_2SiO_2, $(TiO_2)_2$, and $(SnO_2)_2$ respectively, it cannot be concluded that these are adequate expressions for the chemical properties of the substances. The ordinary chemical constitution formula is intimately related to the idea of a molecule, but in the crystalline state the idea of a molecule as an individual system has lost its significance. This fact alone goes far to explain why the chemical constitution formula ceases to express the structure of solids. The final conclusion arrived at is that the substances belonging to the zircon group—zenotime included—have in the crystalline state a structure corresponding to the formula $M_1O_2 \cdot M_2O_2$, which might be called the constitution formula of the solid state; this constitution formula may, however, be quite different from the chemical constitution formula of the substances, or from the constitution of the liquid, gaseous, or ionic form." (P. 531, 1917).

The object in quoting extensively is to show that not only differences of opinion exist with regard to matters relating to valency, but that speculative studies in respect of cohesion (5, first part) probably point the way to a wider or rather a more extended view of the whole subject, whilst *experimental evidence*, as instanced by X-ray analysis (5, last part), is of great value.

A note of caution should be here sounded, namely, that quotations from speculative papers do not necessarily imply that they are to be regarded as anything more than an attempt to solve a difficult problem.

VOLUMETRIC ESTIMATION OF ZINC BY ACIDIMETRIC TITRATION.

By R. HOWDEN, B.Sc Edin.

The zinc should be present as chloride, and the solution should be free from salts of other heavy metals and of ammonium. A sulphuric acid solution does not give good results. Drain off nearly all free acid by evaporation to low bulb, then dilute to about 20 cc. Add a drop of methyl-orange solution, then carefully neutralise with N/10 caustic soda; as zinc chloride is quite neutral to methyl-orange this is easily done. A few drops of phenol phthalein solution are added, and the acid in combination with the zinc is titrated with the N/10 caustic soda. Towards the end of the titration the solution should be heated to boiling, and the termination of the titration is indicated by a pink colour which does not disappear when the solution is boiled. The N/10 NaOH may be standardised against a solution of known concentration prepared from pure zinc. The precipitate of zinc hydrate does not interfere, the end-point is perfectly sharp, and experiment shows that absolutely concordant results can be obtained.

ON THE PHENOMEMA OF FLUORESCENCE.

By DESMOND GEOGHEGAN

Fluorescence was the name given by Stokes to designate certain phenomena which he observed when following up the investigations in the same subject of Herschel and Brewster. Stokes noticed that under certain conditions the rays of light are capable of undergoing a change of refrangibility. Herschel and Brewster had observed that some varieties of calcium fluoride (fluorspar), and also certain other substances when in solution, appeared colourless when looked at by transmitted light, but when viewed by reflected light presented an appearance which varied with the material used, being of a bluish colour in some solutions and of a greenish colour in others. Stokes found that this property, which as before stated he called fluorescence (on account of it having been first observed in fluorspar), is characteristic of a large number of substances other than fluorspar; thus if by means of a lens of long focus, preferably made of quartz, a line of the sun's rays be focussed on a solution of quinine sulphate, rendered more soluble by the addition of two drops of strong sulphuric acid, contained in a glass trough, a beautiful cerulean blue cone of light is formed which is much brighter on the surface and whose intensity rapidly diminishes as it penetrates the liquid.

It thus appears that fluorescence is due or is caused by the rendering visible to the eye of the ultra-violet rays. During the process of the invisible ultra-violet rays becoming visible, certain rays of the spectrum are necessarily absorbed. Thus rays of light which have passed through a sufficient thickness of a fluorescent substance lose thereby the power of exciting fluorescence when they are passed through a second layer of the same substance. As an example of this phenomena the following experiment should be performed by the reader:—Half fill a test-tube with a solution of quinine sulphate or other fluorescent substance and hold the tube in the sunlight. Thus held the liquid appears brightly luminous, but it will lose this luminosity if it be dipped into a trough containing the same liquid which is so arranged that the sun's rays fall on its front. This absorption also results from a comparison of the absorption spectrum of a fluorescent substance with the appearance presented by that substance when the spectrum falls on it. When the fluorescence begins there also begins the absorption, and to a maximum of absorption corresponds a maximum of fluorescence. The phenomena is seen when a solution of quinine sulphate contained in a glass trough with parallel sides is placed in different positions in the solar spectrum. No change is observed in the upper part of the spectrum, but from about the middle of the Frauenhofer lines G and H to some distance beyond the extreme range of the violet, rays of a beautiful sky-blue colour are seen to proceed. These now rendered visible ultra-violet rays also become visible when the spectrum is allowed to fall upon paper impregnated with a solution of æsculin $C_{21}H_{24}O_{13}$ (a glucoside extracted from horse chestnuts, and from the barks of other trees of the Genera *Æsculus* and *Pavia*), an alcoholic solution of stramonium, or a plate of canary glass (which is coloured by means of uranium oxide). If light be allowed to fall upon paper impregnated with barium platino-manganide a beautiful green fluorescence is observed.

Again, if a few drops of a strong solution of fluorescein, $C_{20}O_5H_{12}$, in soda or NH_4OH, be allowed to fall into a large beaker of water in the front of which the sunlight falls, beautiful fluorescent clouds are first produced, and upon shaking the liquid the whole vessel fluoresces with a bright green light.

This change, as with all the phenomena of fluorescence, arises from a diminution in the refrangibility of the ultra-violet rays which are ordinarily too refrangible to render them visible to the eye.

SUBSTANCES DISSOLVED IN RAIN AND SNOW.

By VERNON C. SHIPPLE and LUCIA FORDYCE.

We continued the work of Peck (Chemical News, 1917, cxvi., 283), and analysed forty-one different precipitations, twenty-eight of rain and thirteen of snow that fell between September 29, 1917, and June 1, 1918. The rains and snows during the period are the equivalent of 17·9 inches of rain.

An attempt was made to discover if there is any relation in regard to the time between two precipitations and the amount of the various substances found in the water. Sometimes it seemed that such a relation might be established, but results obtained at other times led us to question any such relation. We came to the conclusion that years instead of months of observation might be necessary to establish a relation of this character.

It is popularly believed that there is a larger amount of nitrates in precipitations that fall during a period of electrical disturbance. Our work failed to show any larger amounts in the rain, even during a severe thunderstorm.

Attention is called to the results obtained from the snowfall of December 5, 1917, as the highest found during the year. It may be explained by the fact that the snow was more or less contaminated by the autumn leaves with which it became mixed.

Except in the early Fall, the highest amounts of sulphates were obtained during the winter, but they were less than those found in the precipitations of the previous year. We have concluded that much of the sulphate comes from the sulphur in coal, and as there was a serious coal shortage during the past season and wood was used instead to a

greater extent than usual, this may explain the smaller amounts.

We tested for phosphate early in the course of this work, and to our surprise we found it to be present. We then made several blank tests using distilled water of unquestioned purity, and in no case did we detect any trace of phosphate. A number of tests for carbon dioxide were made, but we were not able to detect its presence.

OBSERVATIONS ON THE RARE EARTHS.

VI. THE PURIFICATION AND ATOMIC WEIGHT OF DYSPROSIUM.

By H. C. KREMERS, B. S. HOPKINS, and E. W. ENGLE

(Concluded from p. 310).

9. *The Ratio of Dysprosium Chloride to Silver.*

THE first application of this ratio to any of the rare earths was by Baxter and Chapin in their determination of the atomic weight of neodymium (*Proc. Am. Acad.*, 1911, xlvi., 215; *Journ Am. Chem. Soc.*, 1911, xxxiii., 1; *Zeit. Anorg. Chem.*, 1911, lxx., 1). Baxter and Stewart also used this ratio in their work on the atomic weight of praseodymium (*Journ. Am. Chem. Soc.*, 1915, xxxvii., 516). Some very concordant results were obtained by this ratio. Since anhydrous dysprosium chloride could very readily be obtained it was decided to apply the above ratio to this element also.

A preliminary determination was carried out with the use of some sodium chloride. Sodium chloride was re-crystallised three times from conductivity water and freshly prepared hydrochloric acid. Each yield was centrifugally drained. A sample of this was fused and weighed, transferred to a glass-stoppered Jena Erlenmeyer flask of 1·5 litres' capacity, and dissolved in conductivity water. Silver was weighed out to within a fraction of a mgrm. of the calculated amount. This was dissolved in pure nitric acid in a 750 cc. Erlenmeyer flask containing a column of bulbs to retain the spray. The silver nitrate solution was diluted and added to the salt solution and the flask shaken for two hours in a dark room. On the following day a portion of the clear liquid was tested in the nephelometer and indicated a slight excess of chlorine. The calculated amount of silver was added from a standard solution and the flask allowed to stand for twenty-four hours, when the nephelometer test indicated exact equivalence. In this experiment 2·96480 grms. of sodium chloride required 5·47146 grms. of silver for complete precipitation, giving 0·54186 for the ratio NaCl : Ag. Richards and Wells obtained the ratio 0·54185.

The anhydrous dysprosium chloride, from the oxide-chloride ratio, was dissolved in the quartz flask and the solution transferred to the Erlenmeyer precipitation flask. Assuming the atomic weight of dysprosium to be 162·5, samples of silver were weighed out, being usually within a mgrm. of the calculated amount. The weighed silver was dissolved as described above, diluted to 400 cc., and added to the dysprosium chloride of about the same dilution. The flask was then shaken for two or three hours and allowed to stand for forty-eight hours. The solution was then cooled to nearly 0° in order to reduce the solubility of the silver chloride and portions tested in the nephelometer. Portions of standard solutions of silver or sodium chloride were added until the nephelometer test indicated equivalence. After each addition of standard solution the flask was shaken for one hour and allowed to stand for twenty-four hours. In order to determine whether true equivalence was obtained the following experiments were carried out:—After equivalence had been obtained in Sample 1, approximately 1 mgrm. excess of silver was added, and after standing for twenty-four hours the exact equivalent of sodium chloride was added. The following day exact equivalence was again found in the solution. In Sample 2 after equivalence had been obtained 1 mgrm. excess sodium chloride was added. After twenty-four hours its equivalent of silver was added. Equivalence was again obtained in the solution. From the foregoing tests it was proven that true equivalence was obtained in the solutions. In Sample 3 the silver ratio was not obtained because of loss in the transfer of the solution.

The weighings were carried out in the same manner as described under the oxide-chloride ratio. The specific gravity of silver was taken as 10·53 and its atomic weight as 107·88. The following values were obtained by the chloride silver ratio:—

Sample.	Weight of $DyCl_3$.	Weight of silver.	Ratio $DyCl_3$: 3Ag.	Atomic weight
1.	1·04979	1·26301	1 : 1·20309	162·62
2.	1·95604	2·35380	1 : 1·20334	162·57
3.	1·00255	—	—	—
4.	1·47475	1·77504	1 : 1·20362	162·51
5.	1·26253	1·51991	1 : 1·20386	162·45
6.	0·99677	1·20033	1 : 1·20421	162·38
7.	2·23374	2·68806	1 : 1·20338	162·56
8.	1·20763	1·45325	1 : 1·20339	162·56
9.	2·25129	2·70992	1 : 1·20371	162·49
		Mean ..	.. ..	162·52

Since the chloride-silver ratio gave values considerably lower than the oxide-chloride ratio, an attempt was made to determine whether a constant error existed in either one or both of the ratios studied. The difference in the results might be caused by one or more of the following possibilities:—

1. Absorption of hydrogen chloride by the anhydrous dysprosium chloride, thus giving a lower atomic weight with the chloride-silver ratio and a higher value with the oxide-chloride ratio.

2. Volatilisation of the dysprosium chloride, thus giving a higher atomic weight with the oxide-chloride ratio without affecting the result with the chloride-silver ratio.

3. Incomplete decomposition of the oxalate in igniting to the oxide. The presence of a small amount of carbonate in the oxide would give a higher atomic weight with the oxide-chloride ratio. This would not affect the chloride-silver ratio.

To determine whether hydrogen chloride was absorbed a sample of the anhydrous chloride was prepared in the usual way, and after fusion the hydrogen chloride was replaced by pure nitrogen. After all traces of hydrogen chloride had been swept out of the flask the chloride was gradually brought up to the fusion-point by means of an electric furnace. A current of nitrogen was continually passed through the flask, and from the outlet tube was bubbled through silver nitrate solution. As the salt began to fuse a gradual evolution of chloride ion was noticed. This slow evolution of chloride ion was not diminished even though the salt was kept fused for two hours. Upon solution of the dysprosium chloride in water a slight amount of basic chloride was formed. Since the evolution of chloride ion was not sudden at the point of fusion but began to be evolved gradually after fusion had taken place and continued to be evolved seemed to indicate that the source of the chloride ion was from the decomposition of the dysprosium chloride only.

No deposit of the chloride was noticed in the cooler outlet tube of the flask. Hopkins and Balke found that their anhydrous yttrium chloride did not occlude any hydrogen chloride (*Journ. Am. Chem. Soc.*, 1916, xxxviii., 2333).

Another example of oxide was weighed and the chloride dehydrated in the regular way but not fused. The temperature was then kept at 360° for 144 hours while hydrogen chloride was continually passed through the

* Part of a thesis submitted by H. C. Kremers to the Graduate School of the University of Illinois as partial fulfilment of the requirements for the degree of Doctor of Philosophy. From the *Journal of the American Chemical Society*, xl., No. 4

flask. At the end of this time the determination was completed in the regular way. The ratio 1 : 1·43933 was obtained, giving an atomic weight of 163·509. This indicated that there was no volatilisation of the chloride at this temperature. Engle and Balke in their determination kept the temperature at this point for two hours. In the determinations as described in this paper the temperature was not held at this point for any length of time.

Engle and Balke obtained as a mean of five determinations the value 164·228. This value is considerably higher than that obtained in the present work. Incomplete decomposition of the oxalate in ignition to the oxide might account for this high value. The oxide in determination No. 5 of the present work was ignited considerably higher than the other samples, and was found to give a much lower atomic weight by the oxide-chloride ratio. Since the values obtained by the chloride-silver ratio were lower than those obtained by the oxide-chloride ratio of both the present and the former investigations, it seemed possible that in neither case had a pure oxide been obtained.

Dr. E. Wichers, working in this laboratory on the oxide-chloride ratio for erbium, discovered that his erbium oxide contained some carbonate. The dysprosium oxide in the present investigation was tested in a manner similar to that followed by Dr. Wichers. A sample of the oxide was ignited in the regular way for seven hours at 800° and one hour at 900°. The oxide weighed 0·9299 grm. The oxide was introduced into the flask in the regular way and the flask connected to the train. Previous to this the dilute sulphuric acid in the first tower of the train had been replaced with 10 per cent sodium hydroxide solution and air passed through the train until no test for carbon dioxide could be obtained by passing the exit gases through Geissler bulbs containing lime water. The exit tube from the flask was connected by means of a two-way stopcock to two Geissler bulbs containing freshly prepared lime water. Air was passed through for some time and the exit gases passed through one of the Geissler bulbs. No visible precipitate was obtained. The exit gas was now directed through the other Geissler bulb by turning the stopcock. While the air was passing, the inlet tube of the reaction flask was loosened and dilute nitric acid introduced. By allowing the acid to seep through the ground joint a seal was thus made and the slight back pressure in the flask prevented the air from entering. The inlet tube was now replaced and air allowed to pass for one hour. Meanwhile the flask was warmed to 60° and the oxide dissolved. Quite an appreciable precipitate could be noticed in the lime water at the end of this time. From the result of this test it was proven quite conclusively that the oxide as prepared contained some carbonate. This no doubt accounts for the high result obtained by the oxide-chloride ratio.

Since platinum became too volatile and distilled into the oxide when ignited for any length of time above 900° an attempt was made to ignite at a much lower temperature in high vacuo. Accordingly a platinum boat containing the oxalate was placed in a quartz tube and ignited for eight hours at 700° by means of an electric tube furnace. During this ignition the quartz tube was kept evacuated to less than 1 mm. pressure. The tube was then allowed to cool, and dry carbon-dioxide-free air was allowed to enter until atmospheric pressure had been reached. The transfer of the oxide to the reaction flask was made in an air-tight box. This box was made of wood well impregnated with paraffin and contained a sliding plate-glass cover. The reaction flask was placed in the box and the end of the quartz combustion tube was fitted into a hole cut in one end of the box. Dry carbon-dioxide-free air was passed into the box for some time, and in addition an open dish of solid potassium hydroxide was placed inside to absorb the carbon dioxide. By inserting the hands into rubber gloves fitted into holes cut in the sides of the box the boat could be drawn from the tube and the transfer made with the minimum amount of carbon-dioxide present. The value obtained by the oxide chloride ratio in this case was 167·46 as the atomic weight. Two more determinations were carried out by this modification. In place of the platinum boat an alundum boat of the highest grade alundum was used and a temperature of approximately 950° was maintained in the ignition. The values 164·26 and 167·61 were obtained.

One more modification was tried. Two samples of the oxalate were ignited in an alundum crucible for ten hours at a temperature of 1000°, and the transfer was made in the regular way as described in the former part of this paper. The values obtained were 164·55 and 164·40.

It seems probable that the oxide when allowed to cool absorbs carbon dioxide with extreme rapidity and does not lend itself to the manipulation as here used. It also appears that the hot oxide when transferred in the air absorbs enough carbon-dioxide to vitiate the results. From the experimental data obtained it seems quite evident that the oxide-chloride ratio cannot be applied to dysprosium by the methods thus far tried. The ratio is accordingly being abandoned in favour of the chloride-silver ratio which has given good results in this laboratory.

10. *Summary*.

1. Dysprosium material already in a high state of purity was further fractionated as the ethyl sulphates and the bromates. The ethyl sulphates were found to be more efficient for the separation of dysprosium from neodymium, praseodymium, and terbium. Neither of the two methods was found efficient for the separation of dysprosium from holmium.

2. The hydrate, $Dy_2(SO_4)_3.8H_2O$, was not found to be constant in composition when dried over sulphuric acid.

3. The ratio $Dy_2O_3 : DyCl_3$ was further studied. The value 163·83 as the atomic weight was obtained as the mean of nine determinations. A study has been made to account for the difference of this value and that of a higher value (164·228) obtained in a previous investigation.

4. In studying the ratio $DyCl_3 : 3Ag$ the value 162·52 was obtained as the mean of eight determinations. A comparative study of the two values has been made to account for the difference in the values obtained by the two methods.

5. The dysprosium oxide as prepared for the oxide-chloride ratio by ignition of the oxalate was found to contain some carbonate. Several different methods for preparing a pure oxide were tried, but by no method could concordant results be obtained by the oxide-chloride ratio.

6. The results obtained by the oxide-chloride ratio are accordingly discarded in favour of the results (162·52) obtained by the chloride-silver ratio.

PROCEEDINGS OF SOCIETIES.

INSTITUTE OF CHEMISTRY.

LOCAL SECTION FORMED AT LIVERPOOL.

IN accordance with the decision arrived at at the Extraordinary General Meeting of the Institute of Chemistry held on April 27, local sections are now being formed in various important centres.

The Inaugural Meeting of the Liverpool and North-Western Section of the Institute was held at the North-Western Hotel on Thursday, September 12, Mr. G. Watson Gray in the Chair.

The Registrar, who was in attendance by the direction of the Council, referred to the objects to be attained by the establishment of local sections as follows:—

(*a*) To create a local organisation for Fellows and Associates of the Institute, to maintain the status and advance the interests of the profession of chemistry, to afford opportunities for intercourse amongst the members, to arrange conferences and

the delivery of lectures, and to provide for the acquisition and dissemination of useful information connected with the profession and the work of the Institute.

(b) To give information to candidates desirous of joining the Institute, to report to the Council of the Institute when requested on applications from such candidates, and to provide for assistance, if desired by the Council, in the supervision of local examinations of the Institute.

(c) To advise the Council with respect to matters of local professional interest.

(d) To report to the Council on the transactions of the Section with a view to publication in the *Proceedings* of the Institute.

(e) To co-operate with the Registrar in connection with the Appointments Register of the Institute.

(f) When found practicable to form a library or museum, or both.

The Committee and the Secretary of the Provisional Liverpool Section (Mr. John Hanley) were appointed to act in the same capacity for the newly-formed body.

The draft rules for local sections and a new scheme for the election of the Council of the Institute were discussed, and the views of the Liverpool Section on these matters will be reported to the Council of the Institute at an early date.

It is anticipated that local sections will also be inaugurated, during the coming session, at Manchester, Birmingham, Edinburgh, Glasgow, Gretna, and probably other centres.

THE SALTERS' INSTITUTE.

Sal sapit omnia.

THE Salters' Company have at this critical period in the nation's history decided to establish an Institute of Industrial Chemistry. There can be no two opinions as to the value to the country of such a step, and we can confidently look forward to a rapid development of the scheme.

The particulars of the proposed institute are given below, and are in every way commendable. As the success of the institution will very largely depend upon the Director we hope that the company will be fortunate in its choice of the man to fill the appointment. The holder of such a position should, of course, possess the highest technical qualifications; but what is of even greater importance he should have that enthusiasm and "will" power which will infect his students and raise their work above the mere acquisition of the knowledge of present-day chemistry.

We heartily congratulate the Salters' Company upon their patriotic decision and wish it very great success.

SCHEME FOR THE ESTABLISHMENT OF THE SALTERS' INSTITUTE.

1. An Institute will be established to be called "THE SALTERS' INSTITUTE OF INDUSTRIAL CHEMISTRY."

2. The Institute will be, at present, at the Salters' Hall.

3. The Institute will be placed in charge of a Director possessing an exceptional knowledge of Scientific and Industrial Chemistry, who will establish relations with the various Universities and Technical Institutions, as well as with the various branches of the Chemical trade, in order that he may be in a position to assist Students and others desirous of becoming Industrial Chemists as to their course of study and the best openings for their work. The principal duties of the Director will be:—

(a) To make arrangements with Universities and Institutions to enable Students to obtain facilities for Research and Technical Training.

(b) To arrange between Manufacturers and Students and Universities, for the investigation of any particular problems requiring research.

(c) To give practical advice and information to those who are, or intend to become, Industrial Chemists, and especially to men whose careers have been interrupted or affected by Naval, Military, or National Service.

(d) To advise the Company generally as to the progress and any possible extension of the work of the Institute.

4. The Company will establish two types of Fellowships for which Post-graduate Students of any recognised University will be eligible. The two classes are as follows:—

(i.) Fellowships to enable Post-graduate Students to continue their studies at an approved University or other Institution under the general supervision of the Director of the Institute.

(ii.) Industrial Fellowships to enable suitably equipped Chemists to carry on research for any particular Manufacturer, under an agreement which will be entered into between the Institute, the Manufacturer, and the Fellow.

5. Grants in aid may also be made to a certain number of persons who desire to improve themselves in the knowledge of their particular work by attending Technical Establishments or Evening Classes, at which they can obtain a better grasp of their subject.

BRITISH ASSOCIATION OF CHEMISTS.

WITH a view to the establishment of a Birmingham Local Section of the British Association of Chemists a meeting of chemists of Birmingham and the Midlands was held at the University on September 26. Mr. P. L. WILSON (Coventry) presided over an attendance numbering nearly 100.

The Chairman explained that the object was to discuss the policy of the British Association of Chemists and to elect a local committee. In London and in other districts local committees had been formed, and his belief was that Birmingham was now prepared to fall into line.

Prof. HINCHLEY (London) delivered an Address, in which he urged that in the industrial reconstruction which was to take place after the war the chemist must be given a proper and adequate place. The Ministry of Reconstruction was, like the British Association of Chemists, feeling its way. The proposals embodied in the Whitley Report would figure largely in reconstruction policy, and it was essential that professional men generally should assist the Government by giving it the benefit of their collective opinion. In the chemical trade the Council had already been formed, but only the employer and the workman were represented. The chemist was at present without representation. He was in the intermediate position, but the importance of his views could hardly be overestimated. There were few industries in which the chemist did not play a part, and it seemed to him that he was more likely to take long and sane views than either the employer or the worker. The time had arrived when the industrial chemist should face facts. He was not organised. There existed, of course, the Institute of Chemists and a number of excellent educational societies, but little attention was given to economic considerations. The question of remuneration must be gone into. Before the war there were in some districts chemists who were receiving less money than the ordinary workers. The fault of the chemist was that he was too much of an individualist, and it was desirable in the interests of his profession that there should be more *esprit de corps*. The aim should be for collective betterment. Many positions ought to be filled by chemists which were occupied by men who were not chemists; they saw medical men acting as analytical chemists. In a monetary sense the position of the industrial chemist had improved during the war, but the point to be considered was whether that improvement would be maintained. Unity for protection was wanted.

The question of qualification was a difficult one; but 'e thought it could be satisfactorily dealt with. "What) a chemist?" It was like the question: "What is an ngineer?" The chemist was a man who used his brain) solve chemical problems. There were many invaluable ıen besides the research chemists. Some regard must e had for laboratory practice if the academic qualification 'ere absent. The line to be drawn must not be too harp; there should be grading; but a main consideration 'as that the interests of all, the rank and file, must be rotected. The British Association of Chemists was ormed because it was felt that there was something rong with the organisation of chemists—something rong with the Institute of Chemistry. The latter had een gingered up by the British Association of Chemists, ıd as it was rapidly gaining members he was glad to el that it would soon be a strong body. It should be ole to tackle legal and parliamentary questions which ould not be dealt with by a protective association. He elieved the Institute was now a real live body, and doing ccellent work.

Professor Hinchley pointed out that the regulations the British Association of Chemists were in draft rm, but they had yet to be further revised. Still e felt that local sections might get to work on the basis the regulations, and that chemists might be organised districts or by industries. Each section elected a comittee, and each committee sent a delegate to the Central xecutive. Local sections would be given as much itonomy as possible, but care must be taken not to conct with the main principles provided in the regulations. was desirable that the local sections should confer with e main body before making any departure. In their work in anchester his efforts had been directed towards obtaining ıanimity on the committee. "I am not ashamed of the ord 'trades-union,'" said the Professor amid applause. A large number of chemists are ashamed of that word. either employers nor workers are ashamed of the word, ıd I do not think chemists need be ashamed of it. I am rfectly in agreement that 'the strike' as a weapon nerally hurts the people who strike more than the people gainst whom it is directed. In a well-organised comunity it ought to be possible to solve questions without riking and without any methods of warfare (hear, hear), ıd yet we see great nations adopting warfare on the ilure of negotiation." On the question of registration the British Association of Chemists nothing had been ttled yet; there were several alternatives, but in Manıester the legal view was that it would be advisable to gister under a special clause of the Companies' Act.

Mr. BLACKWELL (Aston), Hon. Sec. of the Birmingham ection of the National Association of Industrial Chemists, oke of the progress made by this body (which recognised e trades union spirit), and stated that the National ecutive had been in communication with the Ministries Labour and Reconstruction. The final issues of the nferences would shortly be published; these would show at the National Association would be represented on the uncils in connection with the Whitley Report and Renstruction. It had been suggested that the Association ıs a Lab-boys' union, and that it was attached to the nelter's Union; that suggestion was due to the fact that e Association originated at Sheffield. It had no asciation with the Smelter's Union, and it was not a ıb-boy's union (hear, hear). Many of their members ere chief chemists. The Association fully recognised e importance of technical efficiency, and in Birmingham series of classes had been organised by it; three of such ısses were now in operation. At the Association's Midıd headquarters, the Birmingham Chamber of Comerce, an up-to-date chemical library was being formed. oreover, the National Association was the only body ıt had attempted to form an employment bureau. The sociation's bureau was in working order, and only cently fifteen chemists were supplied through it to the vernment, who made application to the bureau. At the first meeting of the Reconstruction Council the Association's representative would ask that a living wage should be paid to every chemist in the country (hear, hear). Care had been taken in framing the membership qualifications, and these had been so graded as to provide for the various interests.

Mr. ALEX. E. TUCKER, speaking as an old works' chemist, urged the importance of individual effort among the junior members of the profession. Letters of introduction and the personal warrant constituted the finest of *guarantees and practically assured good appointments.* He did not like the association of the trades union principle in connection with the organisation of the profession. He advised the countenancing of the Institute of Chemistry, which represented the blue ribbon of the profession; it was modifying its rules, and it appeared likely that it would afford facilities for admission for all competent chemists. It appeared to him that the *raison d'etre* of the British Association of Chemists had not been made out.

Dr. PARKER (University of Birmingham) pointed out that the pioneers of the British Association of Chemists insisted upon a high qualification for membership, but it appeared to him that the evidence upon this point was now not altogether satisfactory. The conditions regarding qualification in the National Association were, in his judgment, altogether too elastic. The chemists who started the British Association of Chemists made the mistake of asking for the views of all chemists, and he suggested that the influence of the textile chemists, many of whom were not properly qualified, was altogether too dominant on the Executive.

Mr. RHEAD took exception to the latter statement, and pointed out that when important decisions were arrived at at Manchester 100 qualified chemists were present.

At the request of the Chairman, Prof. Hinchley and Mr. Blackwell explained the qualifications for admission to the British Association of Chemists and the N tional Association of Industrial Chemists respectively.

Mr. F. C. A. H. LANTSBERRY (Birmingham) stated that he was one of the pioneers of the British Association of Chemists, but he could not see eye to eye with the present policy of the Executive. Instead of his difficulties being removed they had increased. When the Executive Committee met the Council of the Institute the former stated that if the Council would reform itself on lines which were indicated there would be no necessity for the continuance of the Brit'sh Association of Chemists. The Council of the Institute decided upon a policy of reformation. In these circumstances he failed to see why the British Association of Chemists should continue in existence. The Institute had already shown that it intended to carry out its promises, and he had received an official request asking him to form a Birmingham section as soon as he possibly could. The interests of chemists did not require the aid of three societies. The difficulty in the organisation of chemists was in regard to qualification. Those of the National Association did not compare satisfactorily with those of the British Association of Chemists, and his view was that the latter's objects could be attained by the Institute. Chemists who considered that they had qualifications for the Institute should apply for admission, or join one of the local sections which would be formed upon definite lines.

Mr. RHEAD denied that any agreement was made that the British Association of Chemists would go out of existence if the Institute did certain things. That was an unfortunate misunderstanding. The British Association of Chemists' function was in one sense quite distinct from that of the Institute, in that it would pay close regard for economic questions. Later on it might be well to tighten up the British Association of Chemists' "qualifications"; but at the present time too much attention could not be paid to the academic question. More *esprit de corps* was essential in the ranks of chemistry, and there should be no antagonism among the various organisations.

Mr. S. C. FARRAR urged the importance of clearly settling the qualification question at the present time.

In bringing the discussion to a close the CHAIRMAN stated that, in view of the ambiguity of the admission conditions to the National Association, he could not regard it as a qualifying body. At the same time there was work on the economic side which it could do, and he hoped that it, as well as the British Association of Chemists, would flourish. He felt that the average professional chemist must have a higher standard upon which to work than that stipulated by the National Association; while with regard to the British Association of Chemists he cherished the hope that later on it would be prepared to improve its qualifications on the lines of the Institute which was the qualifying body. On the economic side the British Association was in advance of the Institute; still he thought the two might work together.

On the motion of Mr. G. B. STONES, seconded by Mr. W. H. STOKES, the following resolution was passed:—"That this meeting resolves itself into a group which will consist of all those chemists who desire to remain members, or to become members, of the British Association of Chemists." A committee of twelve to carry on the business of the Birmingham section was appointed.

SOCIETY OF CHEMICAL INDUSTRY.

PROPOSED CHEMICAL ENGINEERING GROUP.

IN connection with the proposal to form a chemical engineering group of the Society of Chemical Industry a postcard canvas is being made of the members. The questions, to which a reply is asked, include the following:—1. "Are you interested in the development of chemical engineering?" 2. "Are you in favour of the formation of a chemical engineering group, or section of the Society of Chemical Society?" 3. "Would you prefer that a separate organisation of the Institute of Chemical Engineers be formed?" 4. "Are you in favour of the formation of a separate organisation as in (3) above, in the event of failure on account of legal or other difficulties to establish a group or section of the Society of Chemical Industry?"

NOTICES OF BOOKS.

Chemical French. By MAURICE L. DOLT, Ph.D. Easton, Pa.: The Chemical Publishing Co. London: Williams and Norgate. Tokyo: Maruzen Co., Ltd. 1918. Pp. viii+398.

THIS book contains a series of graduated exercises in French on chemical subjects, and is designed for the use of students who want to acquire a knowledge of the language for the purpose of taking advanced degrees. The first exercises are quite easy and suitable for beginners, though those who knew no French whatever would have to have a good grammar to refer to or they would make very little headway. The later exercises deal with subjects in inorganic chemistry, analysis, organic, physical, and industrial chemistry, while the second part of the book contains original articles published in various scientific journals by some of the best known French chemists. Good vocabularies are given for each exercise, as well as a complete alphabetical vocabulary at the end of the book together with a table of the principal parts of the irregular verbs. The vocabularies will undoubtedly be found very useful, as they give many words and phrases which are not to be found in an ordinary dictionary, and the subjects of the exercises are chosen so as to cover a very wide range. No grammatical rules or explanations are given, but the use of the book as an alternative to a text-book and good technical and ordinary dictionaries will probably lighten the average student's labours and give him considerable help in reading scientific French.

Rothamsted Experimental Station Report, 1815-17. Harpenden: D. J. Jeffery. 1918. Pp. 71.

THE "Report of the Rothamsted Experimental Station" for 1915-17 shows that, in spite of difficulties, the more important lines of enquiry which had been begun there before the war are being pursued, although the programme of work has naturally undergone considerable modification. New problems which have recently arisen have had to be investigated, and in order to keep well in touch with practical conditions an ordinary farm of 230 acres has been acquired in addition to the experimental area. The special work done includes, among other subjects, the study of the breaking up of grass-land, and some valuable results have already been obtained, while there still remains much to be done. The morphology of the wireworm is to be made the subject of special investigations, and it has already been found that it is extraordinarily resistant to various poisons, the best soil sterilisers apparently being heat. There is need for further work on the organisms of the soil, and problems connected with yields of wheat require investigation; it is pointed out that, in spite of all the experimental data which have been accumulated, the yields of good years are no better than they used to be, although in bad years the average yield is not quite so low as it was forty years ago. The report contains summaries of the papers which have been published by the workers at the station, as well as statistical tables of field trials and other experiments.

Chemistry of Food and Nutrition. By HENRY C. SHERMAN, Ph.D. Second Edition, Rewritten and Enlarged. New York: The Macmillan Company. 1918. Pp. xiii+454. Price 2.00 dols.

THIS book treats of the principles of the chemistry of food and nutrition with special reference to the requirements of man. It is intended primarily for the use of college students, and the readers are supposed to have a fair knowledge of organic chemistry, and might with advantage have previously worked through a short introductory course on the chemistry of foods. Special attention is paid to the subject of dietaries, and some controverted questions are discussed in considerable detail, the views of various workers being carefully analysed, and the author's own conclusions, which are not always in complete agreement with those usually accepted, are given in outline. On the subject of the economic use of food he has some original suggestions to make, and he always makes a special point of weighing evidence and avoiding exaggeration and over-emphasis. Very large numbers of references are given to each chapter, and the student who consulted even half of them would have undertaken a very complete course of reading and should be thoroughly conversant with modern developments of the subject of nutrition.

Circular of the Bureau of Standards. No. 73. *Copper.* Washington: Government Printing Office. 1918. Pp. 103. Price 20 cents.

THIS circular gives accurate information, systematically arranged, as to the physical properties of pure and commercial grades of copper. Methods of manufacture are discussed only in relation to the physical properties, and the presence of impurities and their influence on the properties is also shortly treated. The selection on metallography is illustrated by photomicrographs. Every effort has been made to include only such data as are believed to be correct, and much of the information has been obtained as the results of tests and investigations made by the Bureau. Copies of the circular may be obtained from the Superintendent of Documents, Government Printing Office, Washington.

Lectures on the Principle of Symmetry and its Practical Application in all Natural Sciences. By F. M. Jaeger, Ph.D., Professor of Inorganic and Physical Chemistry in the University of Groningen, Holland. 305 pages with 170 illustrations. Publishing Company, "Elsevier," Amsterdam. 1917.

Prof. Jaeger is to be congratulated upon being one of the few teachers who has been able to pursue his calling unhindered by events that are absorbing the thoughts and energies of most people. The lectures of which the book is the outcome were delivered at Gröningen during 1916-1917, and the publication of such a work at the present juncture is greatly to the credit of the author and his publishers.

The book is dedicated to William Jackson Pope, for whose researches in crystallography the author expresses his admiration.

The principle of symmetry is universal, extending into the domains of both animate and inanimate nature. Research in the sphere of its highest development in crystalline matter has recently received a very great impulse by Prof. Laue's discovery of the diffraction of X-rays by crystals and by the subsequent work of Friedrich Knipping and Bragg.

The author deals exhaustively with the Röntgen patterns given by various crystal substances, and lays stress on the great aid that this means of analysis has proved in the hands of Prof. Bragg and his son.

Much space in the book is devoted to the evidences of symmetry in animate nature, and numerous remarkable *illustrations are given in the geometrical forms of diatoms*, plants, seeds, and the lower animals.

As might be expected from an author of such standing, each of the numerous branches of the subject is developed very fully, and very free use has been made of illustrations, greatly helping to make his meaning clear.

The book makes a valuable addition to the literature of this deeply interesting subject, and will doubtless be used as a book of reference by teachers in physical chemistry. Full references are given to authorities quoted, and there is a thoroughly good index.

CORRESPONDENCE.

THE KING'S FUND FOR THE DISABLED.

Who will Follow His Majesty's Lead?

To the Editor of the Chemical News.

Sir,—His Majesty the King has been graciously pleased to give not only his name, but also the magnificent sum of £78,000 to the fund which was recently inaugurated to assist disabled officers and men of the Navy, Army, and Air Force to become useful members of the community again.

We, the Trustees of the Fund, for whom I sign as Chairman, appeal to the humanity, the gratitude, of every one of your readers, man, woman, and child, for a subscription which will help to find a new place in civil life for officers and men of His Majesty's Forces disabled in the war, and for the widows and children of officers and men who have given their lives for us.

"Why doesn't the Government do that?" some readers will ask.

Briefly, a State Pension scale must be hard and fast. Outside that scale there is a greet human field which the King's Fund can cover, in which the officer, the man, or the dependent can be put on his or her feet and given a sound re establishment in civil life.

A State scheme must be a classification according to the type; the King's Fund passes beyond classification, and acts, not as a public official, but as a private friend.

The present facts are:—

We are receiving 600 applications a week. 2500 cases have been dealt with thus far. Where the officer or man has been trained by the Ministry of *Pensions, or where there is a business given up* for war service, which he can restart, an adequate grant can be made.

The Fund is a Monument of Gratitude.

It will cheer our gallant fighters to see that monument rising to £3,000,000—the amount aimed at.

So let us, therefore, have the money—and quickly. Urgent cases are waiting.

The King leads off with his great gift of £78,000.

Who will follow the King's lead?

Contributions should be sent to the King's Fund for the Disabled, Westminster House, Millbank, S.W. 1.

All cheques and postal orders should be crossed.

For the Trustees,

John Hodge, Chairman.

GERMAN POST WAR PLANS.

Glass a "Key" Industry.

To the Editor of the Chemical News.

Sir,—On behalf of the members of the Glass Industry Interim Industrial Reconstruction Committee which has been formed (under the ægis of the Ministry of Reconstruction, the Board of Trade, and the Ministry of Labour) of an equal number of representatives of Employers' Associations and Employees' Unions in every section of the glass industry, I hope you will allow me to call attention through your columns to the vital significance to this country of certain trade developments contemplated in Germany.

We learn from the German Press that after the war Germany will seek to restore her credit abroad by a concentration of effort upon the export of certain chosen manufactures. Chemicals are named as the first of these manufactures, then comes glass.

Now, Sir, the glass industry of the world is not in the first rank of importance in the eyes of Germany, because of its relative size and volume, or because of the wealth it will *directly* bring to the German people. There is another and a greater reason than that. The reason for *the choice of glass is this: that it is a key to the gate of* many other industries. A nation holding the monopoly of glass could hold up nearly all other trades. We can make hardly anything without using glass at some stage of its manufacture, even if glass is not an actual part of the finished product.

More usually glass is part of the finished product; perhaps in no great quantity, but however small its use, wherever it is, it fulfils a *rôle* that is essential. Our welfare and comfort in health and in sickness, our ships, our trains, our homes, our food—in almost every side and thing of life glass has its place.

And not in peace alone but also in war.

When the history of the war is laid bare it will be found that the difficulty of making glass for lenses and prisms, and for test-tubes, crucibles, and retorts, hampered the work and equipment of our fighting forces to a dangerous extent, and tremendous efforts were needed to save the situation. When the history of the anti-submarine campaign is written it will be found that glass played an important *rôle*.

Before the war the British glass manufacturer and his men had, owing to Germany's hold, little chance of profit or employment. Under war conditions it has been difficult to produce the vital requirements of the country fast enough. There is now opening in this trade for investment of capital and for well paid skilled labour. Will it last? It will be in danger after the war if not supported in a prompt and practical way.

At a recent meeting of the Imperial War Conference there came up for discussion the freeing of industry in Great Britain from dependence on German dyestuffs.

Now you cannot make dyes or any other products without glass. Yet we do not read that the Imperial War Conference has discussed British dependence on German glass!

Our industry is ready to do its part; the manufacturer is ready to put into his works the best available plant, and the workmen are prepared to use this plant to the best advantage. This is a big job, but it does not frighten us. We only ask of our rulers, and of the public, that they will give to glass its proper position in the national life of the country.

We want to manufacture in Great Britain under conditions that will give—(1) security and return to capital, (2) security and a return to brains (management and technical advisers), (3) security and substantial wages and good conditions of employment to our workers.

To put our trade in good position to meet the future progress has already been made. In the Society of Glass Technology we have a common meeting ground for labour, capital, science, and technics, and every branch of the industry is to be represented on our Committee and the District Councils under it. We are organising ourselves.

But this is not enough. Germany's rise has been attributed directly to the English policy of the "open door." We of the glass industry fear that the policy of the open door may be carried to such an extent that the British glass industry may become extinct.

On this point employers and workers think alike. Reform of this condition and help during our reconstruction period is not a political question but a business proposition. The German Government will spare no pains or expense to secure return to their virtual monopoly in optical and chemical glass and their commanding position in glass generally, because they perceive very truly how that return would lead to supremacy in other industries and manufactures. The British glass industry does not intend to allow this return if it can help it. But we ask from our rulers some support. We do not ask them to bolster up an inefficient industry so that we make profits at the expense of the Nation, but we do ask that the industry be given the chance of full development, and that a "key" industry be saved from the hands of Germany, determined to capture it at all costs because it is a "key."—I am, &c.,

JOHN STOKES,
Chairman of the Glass Industry Interim Industrial Reconstruction Committee.

34, Newington Green, London, N. 16,
September, 1918.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

NOTE.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxvi., No. 21, May 27, 1918.

Syntheses in the α-Naphthindol Series.—J. Martinet.—α-Naphthylamine condenses with ethyl or methyl mesoxalate to give an α-naphthodioxindal-carbonate. Either of these ethers can be converted into α-naphthodioxindol by treatment with potash in a current of hydrogen at the temperature of the water bath followed by the addition of hydrochloric acid. When treated with aqueous potash in the air they condense to give the alkaline naphthisatate, from which α-naphthisatine can readily be obtained by treatment with hydrochloric acid.

No. 22, June 3, 1918.

α-Oxycinchonine.—E. Léger.—By heating a solution of basic sulphate of cinchonine with four times its weight of a mixture of equal weights of water and H_2SO_4, the author and Jungfleisch obtained two substances which they regarded as the products of oxidation of cinchonine, for which they suggested the names α- and β-oxycinchonine. Further investigation of the α substance has now shown that it is not an oxycinchonine, but α-oxydihydrocinchonine, formed by the addition of a molecule of water to cinchonine.

No. 23, June 10, 1918.

New Method of Determining Mercury by Zinc Filings.—Maurice François.—In an acid liquid zinc precipitates mercury from its salts, and then the zinc can be dissolved out by means of hydrochloric acid, in which mercury is insoluble. The mercury thus separated from zinc amalgam always masses together to form a globule, in which state it is easily weighed. It is best to convert salts of mercury into the iodide by the addition of potassium iodide, and the sulphide must first be oxidised to give the sulphate. The method is very accurate.

Isatic Acids.—J. Martinet.—By the addition of the calculated quantity of hydrochloric acid to alkaline solutions of the corresponding isatines the author has isolated 5-methylisatic acid, 5·7-dimethylisatic acid, and α-naphisatic acid. These acids dissolve immediately in alkalis, giving yellow solutions without giving the intermediate violet coloration of the corresponding isatines.

The Amide Function.—J. Bougault.—The author's work on the acidylsemicarbazides and the acidylhydroxamides has led him to the conclusion that the acid amides have normally the constitution expressed by the formula RCOH.NH and not R.CO.NH_2, as has hitherto been supposed. He has also shown that the two isomeric series cannot be transformed into one another by simple reactions and are not tautomeric.

No. 24, June 17, 1918.

Direct Transformation of Secondary and Tertiary Amines into Nitriles.—Alphonse Mailhe.—In a previous communication the author and M. de Godon showed that it is possible to transform diisoamylamine and triisoamylamine into isoamyl nitrile by passing the vapours over finely-divided nickel heated to 350—380°. Hydrogen and isoamylene are evolved. It has now been found that the reaction is general, and a great many nitriles have been prepared. The general equations are:—

$$(C_nH_{2n+1})_2NH = 2H_2 + C_nH_{2n} + C_nH_{2n-1}N,$$
$$(C_nH_{2n+1})_3N = 2H_2 + 2C_nH_{2n} + C_nH_{2n-1}N.$$

Isatines containing Quinoline Nucleus.—J. Martinet.—From the dioxindol-3 carbonic ethers and tetrahydroquinoline bases it is possible to obtain substances possessing both an indol and a quinoline nucleus. The alkaline saponification of these ethers in the air gives rise to the corresponding isatates, and from these the isatines can be prepared.

Method of Determining Halogens, Sulphur, and Nitrogen in Presence of Mercury.—Maurice François.—In order to determine the halogens in presence of mercury the latter may be precipitated by zinc filings, when the halogen will combine with the zinc and can be determined in the usual way. To determine sulphur in the sulphide, a hydrobromic acid solution of bromine is added, which converts the sulphide into sulphate. Zinc filings are then added, and after filtration the sulphide is estimated in the liquid by precipitation as barium sulphate. Nitrogen in ammoniacal compounds can also be determined by first removing the mercury by zinc filings.

No. 25, June 24, 1919

Constitution of a Salt from Plants from the Cameroons.—A. Lacroix.—The natives of the Cameroon region, by lixiviation of the ashes of plants, extract a salt

consisting essentially of potassium chloride. The author has analysed a specimen of such salt obtained from a plant which is *Panicum crus Galli*. It contained about 83·5 per cent of potassium chloride, 7·1 per cent of calcium potassium sulphate (syngenite), and 3·9 per cent of potassium sulphate. Sodium chloride, magnesium chloride, and silica are also present, but no carbonates.

Decomposition of Glycerin in presence of various Catalysts: Formation of Ethyl and Allyl Alcohols.—Paul Sabatier and Georges Gaudion.—When glycerin vapour is passed over alumina heated to about 360° carbon monoxide, methane, acrolein, and some higher aldehydes are formed. When copper at 330° is used as a catalyst large quantities of hydrogen are evolved, mixed with methane and carbon monoxide, while one-third of the total volume of gas consists of carbon dioxide. The liquid obtained contains allyl and ethyl alcohols, and propyl and other aldehydes. With uranous oxide the reaction is very similar to that with copper, but higher proportions of hydrogen and carbon dioxide are evolved.

Bornylene Camphor and a New Dicamphor, Isodicamphor.—Marcel Guerbet.—When sodium methylate acts on camphor a small quantity of bornylene camphor is obtained, but the chief product of the reaction is a compound of formula $C_{20}H_{30}O_2$ which is a dicamphor, isodicamphor. It yields a mono and dioxime, and the author has prepared its dibrom derivative.

MISCELLANEOUS.

The Ceramic Society.—The Fifth Meeting of the Refractory Materials Section of the Ceramic Society will be held in the Technical College, Swansea, on Thursday and Friday, October 17 and 18, 1918. The Vice-President, Mr. W. J. Jones, Deputy-Controller of Iron and Steel Production, Ministry of Munitions, London, will preside. Several papers will be read. Hon. General Secretary: Dr. J. W. Mellor, Stoke-on-Trent.

Absorption of Methane and other Gases by Coal.—In *Technical Paper* No. 147 of the Bureau of Mines experiments are described on the absorption of gases from various mixtures of coal. The results show that after exposure to air the coal absorbs about twice as much as when freshly mined, the quantities being about 0·08 cc. and 0·16 cc. per grm. of coal respectively. Nitrogen may be absorbed and evolved by coal. Coal in equilibrium with a mixture of nitrogen and methane absorbs gas with a fall in temperature and evolves gas with a rise in temperature. As far as the experiments show the absorption seems closely analogous to the absorption of gases by charcoal.

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Research Chemist wanted. Knowledge of Organic Chemistry and experience in General Metallurgical Analysis essential. No one at present engaged on Government work need apply.—Apply, stating age, experience, and salary required, to your nearest Employment Exchange, quoting No. A 6131.

Research Chemists wanted, with good knowledge of Physical and Electro chemistry. Salary, £200 to £350 according to qualifications and experience.—Apply to the Salt Union, Ltd., Weston Point, Runcorn.

Works Analytical Chemist required. One conversant with Soap Manufacture, Nicotine Extractions, and Agricultural and Horticultural Preparations. State full particulars and salary required.—Address, W. A., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

POLARISCOPE, by Heele, with vernier; 100 mm. and 200 mm. tubes. Almost as new. £11 10s.—Address, Rose, Chemists, Dewsbury.

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THE CHEMICAL NEWS

VOL. CXVII., No. 3059

SPECIAL NOTICE TO SUBSCRIBERS.

THE recent paper restrictions have compelled us to publish only fortnightly instead of weekly for a time, but we are now glad to be able to announce that we are to be allowed a further supply of paper, which will enable us to revert to weekly publication in the near future.

Beginning with No. 3064, to be published on January 3, 1919, the CHEMICAL NEWS will again appear weekly, and the dates of expiration of subscriptions will be adjusted accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their subscription periods. The price will remain unaltered, viz., £1 for fifty-two numbers, or *pro rata*.

ON THE PREPARATION OF FUMARIC NITRILE.
THE ACTION OF HYDROXYLAMINE ON FUMARIC NITRILE.

By L. MCMASTER and F. B. LANGRECK.

THE nitrile of fumaric acid was prepared some years ago in the Chemical Laboratory of Washington University by heating fumaramide with phosphorus pentoxide, but the yield was very small (Keiser and Kessler, *Am. Chem. Journ.*, 1911, xlvi., 523). The constitution of this nitrile was established by transforming it back into fumaramide and fumaric acid (Keiser and McMaster, *Am. Chem. Journ.*, 1913, xlix., 81).

To inquire further into the methods of preparation and the properties of this nitrile is the purpose of this work. At first, experiments were made to improve the methods of making the nitrile and then the action of hydroxylamine upon it was studied.

Preparation from Fumaramide.

Preparation of Methyl Fumarate.—Twenty grms. of pure fumaric acid was dissolved in 120 cc. of absolute methyl alcohol and the solution boiled for eight hours on the water-bath. During the heating a stream of dry hydrogen chloride was passed through the solution. After cooling, the contents of the flask practically solidified. The mass was broken up and the crystals of dimethyl fumarate were filtered off on a suction filter. They were washed with 10 cc. of ice-cold alcohol and dried by drawing air through them while on the filter. Yield, 19·5 grms. of large white glistening leaves; m.p. 102°. The recorded m.p. is 102° (Anschütz, *Ber.*, 1879, xii., 2282). This method was found to give the best yield of several tried. The alcoholic filtrate was evaporated to about 50 cc. and a second crop of crystals obtained. These, however, required a recrystallisation from hot methyl alcohol to rid them of a yellowish colour.

Preparation of Fumaramide.—Nine grms. of the dimethyl fumarate was treated with 35 cc. of ammonia water, sp. gr. 0·90. The mixture was placed in a flask and allowed to stand, with occasional shaking, for twenty-four hours (see Hagen *Ann.*, 1841, xxxviii., 275). The fumaramide formed as a fine white powder. It was filtered off, dried on the filter, and then heated in an air-bath at 110°. The filtrate, containing some unchanged ester, was saturated in the cold with ammonia gas and allowed to stand for twenty-four hours, whereupon further formation of the amide took place. The total yield was 6·2 grms. of fumaramide which melted, after carbonising, at 266°.

Preparation of the Nitrile.—Keiser and Kessler (*loc. cit.*) obtained a yield of 0·15 grm. of nitrile (5·6 per cent of theory), by heating 5 grms. of fumaramide with 15 grms. of phosphorus pentoxide to 120° in a crystallising dish, covered with a cool funnel, on the walls of which the sublimate of nitrile condensed. This method was repeated a number of times, and the best yield we could obtain from 5 grms. of amide was 0·16 grm. of nitrile (6 per cent of theory).

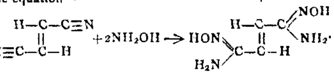
We then carried out the reaction in a retort, and passed a current of dry air over the mixture to carry away the nitrile as fast as it was formed. A water-cooled condenser was substituted for the funnels. The retort was heated to 170° in an oil-bath. Experiments, using 3 grms. of fumaramide, gave yields of nitrile that varied from 12 to 15 per cent of theoretical. It was now decided to carry out the reaction in the presence of dry nitrogen instead of air. The nitrogen was prepared from air by means of Van Brundt's apparatus (*Journ. Am. Chem. Soc.*, 1914, xxxvi., 1448). Twenty five per cent yields of the nitrile were thus obtained.

Attempts were made to prepare the nitrile by heating zinc fumarate with lead, barium, and potassium thiocyanates, but no yields could be obtained.

We also carried out experiments in an attempt to prepare the amide and nitrile of maleic acid. While our work on these compounds has been very much more extended than that previously done in this laboratory, the results were not satisfactory (Keiser and McMaster, *Am. Chem. Journ.*, 1913, xlix., 81).

The Action of Hydroxylamine on Fumaric Nitrile.

Fumaric nitrile, being a dinitrile, should yield a diamidoxime when treated with hydroxylamine according to the equation—



Preparation.—One grm. of fumaric nitrile was treated with 1·77 grms. of hydroxylamine hydrochloride and 1·36 grms. of sodium carbonate, dissolved in 20 cc. of water. After the evolution of carbon dioxide had ceased a clear solution resulted. The mixture was allowed to stand fifteen hours, at the end of which time a bulky white mass had separated out of solution. After filtering, this white mass was recrystallised from hot water and formed as fine white needles. They melted sharply, with carbonisation, at 212°. At temperatures below 212° the crystals slowly blackened, and it was necessary to make the determination by plunging the m. p. tube into sulphuric acid at or near 212°. Yield, 0·32 grm. This procedure was repeated a number of times.

Properties.—The substance is fairly soluble in cold water and very soluble in hot water, from which it crystallises as slender sparkling needles. It is insoluble in ether and cold ethyl alcohol and but slightly soluble in hot alcohol. It is insoluble in chloroform and acetone and readily soluble in glacial acetic acid.

The aqueous solution gives no precipitate with potassium chromate or picric acid solutions. It gives a deep red colour with ferric chloride solution, which is characteristic of amidoximes. Bromine water and alkaline potassium permanganate solution are rapidly decolorised by the aqueous solution. Silver nitrate solution precipitates a white salt from the aqueous solution. This salt, when heated, deflagrates and leaves a residue of silver.

Dry hydrogen chloride passed into the glacial acetic acid solution of the compound precipitates a white substance which is very soluble in water. This precipitate melts at 212°, hydrochloric acid being split off during the heating. Evidently the hydrochloride of the original compound had been formed.

Boiling the compound with water for twenty hours failed to transform it into fumaramide, as was expected.

Analysis.—If the compound is the diamidoxime and has the formula $C_4H_8N_4O_2$, it should contain 38·89 per cent N, 33·31 per cent C, and 5·60 per cent H. We made five determinations of carbon and six of hydrogen, each of which agreed quite well with the figures just given. We made six determinations of N, the results varying from 30·25 per cent to 33·33 per cent. The determinations were made by all the different modifications of the Kjeldahl method. Since we could obtain no check results by the Kjeldahl method, determinations of the amount of nitrogen were made by the Dumas method, which proved to be successful.

Calculated for $C_4H_8N_4O_2$—C, 33·31; H, 5·60; N, 38·89. Found—C, 33·43 (average of five determinations); H, 5·95 (average of six determinations); N, 38·55 and 38·51.

Our results of analysis check quite closely with those calculated for the diamidoxime. The compound has the solubilities in the different organic solvents characteristic of amidoximes. The other reactions mentioned are also those characteristic of amidoximes. We therefore are of the opinion that the new compound prepared by treating fumaric nitrile with hydroxylamine is fumardiamidoxime and has the formula given above.

If, after removing the white mass of fumardiamidoxime first formed in the reaction, we extract the filtrate with ether, there is obtained from the ether extract a yellow cotton-like substance which rapidly darkens when exposed to the air. It melts, with carbonisation, at 105°. Analysis showed it to consist of 43·70 per cent C, 6·49 per cent H, and 25·61 per cent N.§

Summary.

The method of preparation of fumaric nitrile by the action of phosphorus pentoxide on fumaramide has been improved. Twenty-five per cent yields, in contrast to former 6 per cent yields, have been obtained.

The action of hydroxylamine upon fumaric nitrile has been studied, and we have prepared the diamidoxime of fumaric acid. Its properties are described.—*Journal of the American Chemical Society*, xl., No 6.

CONTACT INSECTICIDES.*

Physical Properties Governing their Efficacy.

By WILLIAM MOORE,
Head of Section of Research in Economic Zoology,
and S. A. GRAHAM,
Assistant in Entomology, Minnesota Agricultural Experiment Station.

It was considered by Shafer (16)† that the vapour of contact insecticides such as kerosene, gasoline, creolin, and pyrethrum were responsible for the death of insects to which these materials were applied. It was therefore assumed as a working basis that the volatility of organic compounds, which has previously been shown to be an index of the toxicity of their vapours to insects (11, 12), would also be an index of the toxicity of these compounds when used as contact sprays. In working with insect eggs (14), however, it was found that materials not sufficiently volatile to kill insects or their eggs by their vapour within a reasonable length of time, were among the most effective materials when applied to the eggs as liquids. Further studies in which different fractions of kerosene were used (13) revealed the fact that the least volatile fractions were the most effective as contact insecticides, while they failed to kill insects which were exposed only to their vapour.

With these results in mind it was considered advisable to determine the physical properties governing the entrance into the insect of a contact insecticide, and wherein this differs from the penetration of the vapour.

Wetting and Spreading of the Insecticide.

It is common observation that when some contact insecticides strike an insect they form into round droplets which roll off the body, while others spread out, forming a film over the insect. This phenomenon of the spreading out of the insecticide over the body has been often termed "wetting" or "spreading," and is often confused with the wetting and spreading of the insecticide over the surface of the leaves sprayed, the terms "wetting" and "spreading" being used synonymously. Vermorel and Dantony (18, 19, 20), Lefroy (5), and more recently Cooper and Nuttall (2) have studied the physical principles governing the wetting and spreading of contact insecticides and have endeavoured to devise means by which these important properties may be easily measured. In all of these papers the authors have failed to distinguish between wetting and spreading. In this paper a distinction will be drawn between these two terms. If a liquid is placed upon a solid, and there is a specific attraction between the two, they will come into actual contact. The slight chemical affinity exhibited between the two substances is what is denoted as wetting, or adhesion between the liquid and the solid. For example, if a drop of mercury is placed upon glass, there is no specific attraction between the two, owing to the film of moisture and air on the surface of the glass (3). Hence, the mercury is said not to wet the glass, and there is no adhesion between the two. By boiling the mercury in a glass tube and thus expelling the moisture and air between the mercury and the glass, it is found that there is an actual wetting of the glass by the mercury, as is indicated by adhesion.

If a liquid is brought into contact with a solid and wetting takes place, the spreading of the drop into a thin film may or may not occur. The law governing spreading has been carefully explained by Cooper and Nuttall (2). *They find that if the surface tension of the substance upon* which the spray is placed is greater than the surface tension of the spray plus the surface tension at their interface (interfacial tension), the liquid will spread. Otherwise there will be no spreading. Bigelow and Hunter (1) have given a very much simpler explanation of the whole matter. They consider that if a liquid is in contact with a solid—that is, actually wetting the solid—two forces are at work.

First, the cohesion between the like particles of the liquid which, in the surface layer, is denoted by the phrase "surface tension," and, second, the adhesion between the liquid and the walls (solid).

Thus, if adhesion to the solid is stronger than the cohesion of the liquid, the liquid will spread over the solid. The same law applies when two liquids are in contact. The following experiment will serve as an example:—If a filter-paper is soaked in water and spread out flat on a glass plate, a drop of kerosene on this wet paper *will quickly spread into a thin film. In this case* the adhesion between the water and the kerosene is greater than the cohesion of the kerosene. On the other hand, if the *filter-paper is soaked in kerosene and a drop of water* placed upon it, the water does not spread out into a thin layer. In this case the cohesion of the water is greater than the adhesion between the water and the kerosene, which is the same in both experiments. Thus, it is clear that there must be wetting before there can be spreading, but it does not necessarily follow that when there is wetting there must be spreading, for otherwise the water would have spread over the kerosene.

* *From the Journal of Agricultural Research.*
† Reference is made by number to "Literature Cited" at end of paper.

One other factor has a considerable influence on the spreading of an insecticide—namely, viscosity. Viscosity may be defined as "the internal friction of a liquid." Although the viscosity does not influence the ultimate extent to which a liquid may spread, it does have a very decided influence on the rate of spread. It is possible that a liquid may be so viscous that the rate of spread may be reduced to such an extent as to make it valueless as an insecticide.

From the foregoing statements it is apparent that when a spray strikes an insect, if there is a chemical affinity between the insecticide and the chitin which forms the outer covering of the insect, wetting will take place and the insecticide will adhere. If the cohesion of the spray is less than the adhesion between the chitin and the spray, then the liquid will spread over the body of the insect. The rate at which this spreading will take place is governed by the viscosity of the liquid. If the cohesion is greater than adhesion, the spray will form into droplets which tend to roll off. The same result is obtained when the spray does not wet the insect. It is apparent therefore that in a contact insecticide it is important not only that the liquid should wet the chitin, but also that the adhesion of the liquid to the chitin should be greater than the cohesion of the liquid.

Relation between Spreading and Capillarity.

The rise of a liquid in a capillary tube is governed by the same laws as the spreading of a liquid over the surface of a solid. First, unless the liquid has a specific attraction for the material of which the tube is composed (wetting), there can be no capillary rise. Second, unless the adhesion between the liquid and the walls of the tube is greater than the cohesion of the liquid, there can be no capillary rise. This is well shown by Bigelow and Hunter's (1) studies of the rise of water in capillary tubes of different materials. In their experiments the cohesion of water remained the same, but owing to different degrees of adhesion between the water and the walls of the capillary tubes, variations were noted in the height to which the liquid rose in tubes of different materials. It is evident, therefore, that since the tracheæ are lined with chitin, similar to the covering of the body wall, insecticides which will spread over the body will also penetrate the tracheæ by capillarity, while those insecticides which do not spread over the insect, even though they may come in contact with a spiracle, will not be able to penetrate the tracheæ.

Contact insecticides may therefore be divided roughly into two groups:—First, those which wet the insect, and, owing to greater adhesion than cohesion, are able to spread over the surface of the body and pass up the tracheæ by capillarity. Second, those which wet the insect, but which, owing to a higher cohesion than adhesion, are able neither to spread over the surface nor to gain entrance into the tracheæ by capillarity.

Penetration of Liquids into Tracheæ.

From the results of Cooper and Nuttall (2) it would appear necessary to make determination of the surface tension of the insecticide, the surface tension of the chitin, and the surface tension at the interface of the chitin and the insecticide before it could be determined whether or not the liquid would spread over the body and penetrate the tracheæ. From the results of Bigelow and Hunter (1), however, the capillary rise in a tube really determines whether the adhesion between the liquid and the solid is greater than the cohesion of the liquid, or, in other words, is a means of determining whether the surface tension of the solid is greater than the surface tension at the interface between the solid and the liquid plus the surface tension of the liquid. By placing an insect in the insecticide to be studied for a short period and then dissecting it, it is possible to determine whether or not the insecticide has penetrated the tracheæ, and approximately how far. These results give an index of the spreading ability of the different materials.

The cockroach (*Blatella germanica*, L.) was used in the following experiments for determining the penetration of insecticides into the tracheæ. The results were checked over with certain of the compounds, using the wax-moth larvæ (*Galleria mellonella*), the larvæ of the Indian meal moth (*Plodia interpunctella*, Hbn.), and certain aphids. The methods of procedure were as follows:—The liquid to be tested was stained with Sudan III. or trypan blue, both of which are colloids, and therefore will not pass through a semi permeable membrane. The cockroach was placed into the liquid and allowed to remain for from fifteen minutes to two hours, depending upon the viscosity of the liquid. After a sufficient time had been allowed for the liquid to penetrate, the cockroach was removed and opened on the ventral side. The tracheæ which were penetrated by the material stood out either red or blue, and it was very easy to determine the extent of the penetration.

It was found that aqueous solutions other than soap solutions do not penetrate the tracheæ. It was interesting to note that both nicotine and absolute alcohol are able to penetrate the tracheæ, but when greatly diluted with water they are no longer able to enter. Those substances which in an aqueous solution exhibit surface viscosity, such as saponin, gelatin, and casein, do not penetrate the tracheæ. Those materials have frequently been employed in preparing emulsions (4, 20, 21). Compounds which are soluble in ether or are capable of dissolving fats or oils are able to spread over the body of the cockroach and penetrate the tracheæ. Such substances as acetic acid, furfurol, and nicotine are not particularly good fat solvents, and it may be noted that they did not penetrate any great distance into the tracheæ. Compounds with a high viscosity, such as lubricating oil, failed to penetrate far into the tracheæ; but if these viscid substances had been given a longer time they would undoubtedly have penetrated much further. Some soap solutions, such as ivory, gel at room temperatures in dilutions ordinarily used in spraying (1 : 150 or 200), and are therefore unable to penetrate to any great extent. The penetration of such a soap solution is increased when its cohesion is reduced by raising the temperature of the solution. Soft soap and yellow soap were liquid at the same dilution and penetrated better than Ivory soap, while Castile soap, manufactured from the liquid oleic acid, penetrates very well.

According to Morgulis (15) the exact chemical composition of chitin is still questionable. From our results its composition must be such that it is easily wetted by oils and oil solvents, or perhaps the surface of the chitin itself contains or is coated with an oily or a fatty substance. These results cannot be applied to all insects, as some have special coverings of wax over the chitin. The spreading of sprays on such insects can, however, be determined by our methods with little trouble.

Relation of Viscosity and Volatility to the Penetration of the Tracheæ.

The foregoing results have been primarily concerned with the pure materials. Inasmuch as the pure materials are seldom applied in actual practice, the question arises as to what takes place when an emulsion of an oil is used in spraying. By placing drops of the emulsion on the wings and also on the bodies of cockroaches, it was found that the oil droplets were completely surrounded by the emulsifier and did not come in contact with the body of the insect. The ability of such a spray to adhere to the insect, to spread over the body, and to penetrate the tracheæ depends therefore on the character of the emulsifier and not on the emulsified oil. Three distinct types of emulsions were noted:—First, emulsions made with gelatin or saponin formed a round drop and tended to roll off the insect, just as did pure aqueous solutions of these materials. Second, emulsions made with Castile or soft soap adhered to the insects and spread over the body,

penetrated the tracheæ, carrying the emulsified oil with them. Third, emulsions made with using Ivory soap adhered to the body of the insect; but, owing to the high cohesion of the liquid, spread very slowly. In the third case it was noticed that in a comparatively short time, depending upon the temperature and humidity of the surrounding atmosphere, the water evaporated and the emulsion broke down, after which the oil spread over the surface of the body, penetrating the tracheæ. The length of time required for the breaking of the emulsion was from five to thirty minutes. If the oil was rather volatile it would evaporate before it succeeded in penetrating the tracheæ. By spraying a number of insects it was determined that oils more volatile than xylene were too volatile to succeed in penetrating the tracheæ in large enough quantities to result in the death of the insect. On the other hand, the oil may be so viscous that, even after the breaking of the emulsion, it is unable to spread over the body and enter the tracheæ in a reasonable length of time. The viscosity of a number of oils was determined in terms of water by measuring the length of time required for 5 cc. of the liquid to flow through a glass tube of small diameter arranged in the form of a stalagmometer.

By placing a small drop of oil on the wing of a cockroach and watching it under the microscope it was possible to divide the oils into four classes:—(1) Those spreading rapidly, (2) those spreading slowly, (3) those spreading very slowly, and (4) those spreading so slowly as to preclude any possibility of their reaching the spiracles in a reasonable length of time.

Penetration of the Insecticide into the Tissues.

Shafer (16) has shown that contact insecticides, such as kerosene and others of a similar nature, are able to penetrate the tracheæ of an insect, but he considers that it is the vapour from these substances which is responsible for the killing, inasmuch as the rate at which the liquid itself will pass through the chitin is too slow to account for the death of the insect. He dissolved Sudan *III.* in kerosene to show the passage of the oil through the walls of the tracheæ. At the time of the death of the insect he could find no evidence of a red stain in the tissues, and it was not until the insect had been dead for a long time and the fat bodies had been partially dissolved that he could detect traces of the stain in the tissues. Sudan III., however, is a colloid, and would not be able to pass but very slowly through a semi-permeable membrane such as chitin. Thus the inability of the stain to pass through the chitin did not necessarily imply that the kerosene had not been able to penetrate into the tissues. If the experiment is repeated with picric acid instead of Sudan III. it is found that the tissues are very quickly stained yellow. There are, however, a number of objections to the use of a stain to indicate the passage of a liquid, as it is quite possible that the stain could penetrate by being absorbed by the walls of the tracheæ without any penetration of the oil. If a few pieces of chitin are placed in kerosene stained with picric acid they are capable of absorbing practically all the stain from the oil. On the other hand, it is quite possible that the amount of the insecticide which might penetrate and kill the insect would be so small that the amount of stain carried with it could not be detected. Further, it would be impossible to determine the penetration of a vapour by a stain in the insecticide. Chemical tests for insecticides in the tissues in many cases would not be delicate enough for the certain detection of their presence or absence. Finally, after a number of trials it was found that the best method was to use an indicator for dead tissues. Trypan-blue is a water soluble colloid which does not penetrate the living tissues, but is able to penetrate and stain dead tissues. This was selected as the most suitable indicator. Larvæ of the wax moth were used in these experiments. If a living untreated larva is opened and the tissue covered with an aqueous solution of trypan-blue for a period of two minutes and the stain then removed and the larva examined under water, it will be found that there are particles of the stain adhering along the mid-intestine, more or less on the silk glands, and along the nerve cord. This does not seem to be a true staining of the tissues, but rather the adherence of particles of the stain, which are difficult to remove by washing (adsorptions).

When an insect has been treated with an effective contact insecticide and opened and stained just before it dies, the tissues which have been killed are stained a deep blue, thus indicating the point of entrance of the poison. No effort was made in this work to determine which tissues were primarily affected by the chemicals. As a counter stain, to show to what extent the materials penetrated the tracheæ, Sudan III. was used with the oils and resin with the aqueous solutions.

The insecticides may be divided into four different groups:—1. The non-volatile insecticides which as liquids penetrate the tracheæ. 2. The volatile insecticides which are able to penetrate the tracheæ as liquids. 3. The volatile insecticides which only penetrate the tracheæ in vapour form. 4. The non-volatile insecticides which decompose on contact with the insect, producing a vapour which is capable of entering the tracheæ. The results of experiments show that relatively non-volatile oils pass through the walls of the tracheæ only where the liquid has penetrated.

Soap solutions are particularly interesting, since when a soap is dissolved in water it is hydrolysed, some of the soap molecules reacting with the water to form sodium hydrate and the free fatty acid. This free fatty acid acid unites with the fatty acid of that portion of the soap which has not been hydrolysed, forming a sol (10). Since the chitin is a semi-permeable membrane the sol is able to pass through but very slowly into the body of the insect. The sodium hydrate in the solution is no doubt the portion which accounts for death. Experimental evidence shows that solutions of soaps containing a large percentage of free alkali are more toxic than those which are practically neutral.

Volatile oils and acids show a blue staining along the walls of the tracheæ where the liquid has penetrated, and also blue blotches along the walls beyond this point. Examination of insects which have been treated for varying lengths of time show that the blue blotches caused by the vapour of the chemical appear more quickly than the blue caused by the penetration of the liquid itself, showing that the vapour is able to penetrate the walls of the tracheæ more quickly than the liquid. It might be noted here that these results are somewhat modified by the fact that the vapour is passing through somewhat thinner chitin than that through which the liquid must pass.

Aqueous solutions such as nicotine do not penetrate the tracheæ other than in the form of a vapour. The blue in this case occurs in blotches along the walls of the tracheæ. What was evidently a condensation of the vapour appeared in the larger tracheæ and the blue staining of the tissues was particularly strong at these points. This confirms the observations of McIndoo (8), who has shown by chemical means the condensation of nicotine within the tracheal tubes. When nicotine sulphate comes in contact with the body of the insect it is slowly decomposed, with the formation of nicotine which enters as a vapour. Such a decomposition is no doubt the explanation of the results of Lovett (6), who found that leaves sprayed with nicotine sulphate even when dry are repellent and poisonous to insect larvæ, even though not taken internally.

To such aqueous solutions, which normally are not able to enter the tracheæ, the addition of soap increases their efficiency, as it enables the liquid to spread over the body and enter the spiracles. The addition of too much soap will somewhat decrease the efficiency of the spray owing to increased cohesion. Some of the results obtained in the use of nicotine sulphate and fish-oil soap sprays by Smith (17) are thus explained.

In general there was little evidence of penetration of

the insecticides through the body wall. This does not necessarily mean that the compounds are not able to penetrate the chitin, but that they were unable to do so prior to their entrance by way of the tracheæ. Compounds which are readily soluble in water and readily diffuse in aqueous solutions were frequently found to have gained entrance through the anus and through the mouth. Alcohol, acetic acid, and sometimes soap showed such penetration. The more viscous compounds require very much longer to enter the insect than compounds with a low viscosity. Lime-sulphur differs from other contact insecticides in its action, but its action has been fully described by Shafer (16).

Penetration of Fumigants.

Fumigants gain entrance into the insect by way of the tracheæ. In many cases what appeared as a condensation was noticed within the tracheæ, and in such cases blue staining, indicating dead tissues, appeared at these points. These results explain why the volatility of organic compounds should be related to their toxicity (12). The more nearly the atmosphere is saturated with the vapour the more likelihood there is of a condensation in the tracheæ. Even though there is no condensation the same forces are at work. One of these forces is the tendency for the vapour to condense on coming in contact with the chitinous walls of the tracheæ. The other force is the tendency of the compound to re-evaporate from the tracheal walls. In the least volatile this tendency to re-evaporate is generally diminished, while in the more volatile compounds, in order to reduce this tendency to re-evaporate, very large quantities of the chemical must be present in the air. It is thus apparent that an insect may be killed with comparatively small doses of slightly volatile compounds, while it may require a much heavier dose of a more volatile material. The volatility of organic compounds is therefore, in general, an index of their ability to penetrate into the body of the insect, and inasmuch as the compound which cannot penetrate will be unable to kill, it is apparent that the volatility is correlated with the toxicity. One notable exception mentioned in a previous paper (12) is that of chlorpicrin, which in very minute quantities is able to kill the insect. In our experiments in tracing the penetration of fumigants it was noticed that this mateial was able to penetrate the walls of the tracheæ and kill the insect very quickly. This may be due to one of two factors; first, the extreme toxicity of chlorpicrin, or, second, an abnormal power of penetration.

The following experiment throws light on this question. Acetic acid and benzene are of about the same volatility as chlorpicrin. On assuming, therefore, for the sake of the experiment, that their powers of penetration are equal, it was determined to test their comparative toxicity to insect tissues. Three living wax moth larvæ were opened on the ventral side and spread out. One was treated directly with acetic acid, the second with benzene, and the third with chlorpicrin for a period of one-half minute. The chemicals were then quickly removed, and the tissues were washed with water and then treated with trypan blue. The larva treated with acetic acid showed a very intense blue-staining throughout the tissues. The larva treated with benzene showed but slight staining. The larva treated with chlorpicrin showed more staining than benzene but much less than that of acetic acid. Of the three compounds acetic acid was by far the most poisonous to the tissues. In actual fumigation, dipping, or spraying, the death of the insect occurs most quickly with chlorpicrin. This material, therefore, must owe its abnormal toxicity to its ability to be absorbed by the chitin and passed into the body. The reason for this high power of penetration of chitin by chlorpicrin will be the object of further study.

Summary.

From the general results reported in this paper it appears that the physical properties as well as the chemical properties have an important bearing upon the efficiency of the contact spray. Even though the spray may contain a very active poison it will not be effective unless it conforms to certain physical requirements—that is, the ability to vaporise and penetrate in the form of a vapour or to spread over the insect and penetrate in the liquid form. The results reported by McClintock, Houghton, and Hamilton (7) show very clearly that this is true. The results in the use of quassia with or without soap as reported by McIndoo and Sievers (9) are another example, and it is a common observation the the addition of soap to nicotine sprays increases their efficiency. The following are some of the principles which must be kept in mind in studying the effects of contact insecticides.

1. Contact insecticides may be divided into two groups:—(*a*) Those which spread over the body of the insect and penetrate the tracheæ. (*b*) Those which are not able to spread over the insect and do not penetrate the tracheæ.

2. Contact insecticides which are either soluble in ether or chloroform or are fat solvents are able to spread over the insect and enter the tracheæ.

3. The rate of spread of these insecticides is governed by their viscosity and cohesion.

4. Compounds with a viscosity as high or higher than castor-oil spread so slowly that, in general, they may be classed as poor insecticides.

5. Compounds more volatile than xylene evaporate too quickly for effective work.

6. Sprays in the form of emulsions may enter the tracheæ as such, or the oil remaining after the emulsion is broken down may spread over the insect and enter the spiracles.

7. Relatively non-volatile oils penetrate the body of the insect directly through the walls of the tracheæ as liquids, the rate depending upon the viscosity.

8. Volatile oils may penetrate the walls of the tracheæ in either vapour or liquid form.

9. Sprays which are unable to enter the tracheæ in liquid form may penetrate and pass through the tracheal walls as vapour.

10. Fumigants gain entrance and pass through the tracheal walls in vapour form.

11. Slightly volatile compounds tend to condense upon the tracheal walls owing to the fact that small quantities are sufficient to saturate the atmosphere. Owing to this high saturation these condensations tend to penetrate the chitin rather than to re-evaporate. Volatility is an index of the ability of the compound to gain entrance into the insect and is therefore closely correlated with toxicity.

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A METHOD FOR THE COLORIMETRIC ESTIMATION OF COBALT.*

By E. GABRIEL JONES, M.Sc., F.I.C.

THE author has recently had occasion to estimate very small quantities of cobalt, of the order of 0·01 to 0·1 per cent, in such materials as varnishes and zinc oxide paints, and has tried various colour reactions of that metal with a view to devising a rapid method of estimating it colorimetrically. A satisfactory reagent for the purpose was found to be a solution of α-nitroso-β-naphthol, as prepared by Atack (*Journ. Soc. Chem. Ind.*, 1915, xxxiv., 641), and by the addition of ammonium citrate to the solution under examination the effect of moderate quantities of many other metals was eliminated. The ammonium citrate solution was prepared by dissolving 500 grms. of citric acid in 250 cc. water and adding 500 cc. ammonia (0·880). This solution contains excess of ammonia.

The procedure in the case of varnishes was as follows:—A weighed quantity was incinerated in a porcelain crucible and the ash treated with concentrated hydrochloric acid; in case any insoluble matter remained aqua regia was added, followed later by hydrochloric acid to remove the nitric acid. After evaporation to dryness the residue was dissolved in hot water with the addition of a few drops of dilute hydrochloric acid, and the solution made up to a convenient volume. An aliquot part was transferred to a Nessler cylinder, 5 cc. ammonium citrate solution added, the mixture diluted nearly to 100 cc., and 5 cc. of the α-nitroso-β-naphthol solution added; the contents of the cylinder were then mixed. The colour of the liquid was matched against different quantities of a standard cobalt solution, to which were added the same amounts of ammonium citrate and α-nitroso-β-naphthol as used with the sample. It is essential that the quantity of free ammonia should be nearly the same in all the solutions compared. The most satisfactory quantity of cobalt for comparison was found to be about 0·1 mgrm.

The following experiments were made with varnishes to which known amounts of cobalt were added:—

Per cent Co added.	Per cent Co found.
0·0095	0·009
0·039	0·037
0·066	0·062
0·072	0·070
0·104	0·103
0·180	0·178

The *mineral matter of these varnishes consisted mainly* of ferric oxide, with traces of silica and lead, and sometimes minute traces of copper and manganese. In order to ascertain what influence larger quantities of these metals and zinc would have upon the estimation of the cobalt content the following experiments were made:—

Weight of cobalt. Grm.	Weight of other metal added (M). Grm.	Ratio Co : M.	Result
0·0001	0·01 Fe	1 : 100	Quite satisfactory.
0·0001	0·025 Fe	1 : 250	Fairly satisfactory, colour slightly brown.
0·0001	0·01 Zn	1 : 100	Quite satisfactory.
0·0001	0·1 Zn	1 : 1000	Quite satisfactory.
0·0001	0·0005 Mn	1 : 5	Co 0·000095. Results correct if allowed to stand half-hour).
0·0001	0·001 Mn	1 : 10	(Co 0·000095. Results correct if allowed to stand half-hour).
0·0001	0·005 Pb	1 : 50	Quite satisfactory.
0·0001	0·0001 Cu	1 : 1	Satisfactory.

A further experiment was made in which 0·0001 grm. cobalt was mixed with 0·01 grm. Fe, 0·1 grm. Zn, 0·001 grm. Mn, 0·005 grm. Pb, and 0·0001 grm. Cu; the colour obtained under the above conditions exactly matched that given by the cobalt alone.

Modifications of the above method were necessary in presence of (1) copper, except in minute traces; (2) nickel; and (3) manganese in large quantities. The following methods were found to give satisfactory results in such cases:—

1. *Copper.*—When the amount present exceeded a minute trace it was removed by hydrogen sulphide, the acidity of the solution (with hydrochloric acid) being about N/20; after boiling off the excess of hydrogen sulphide from the filtrate the correct coloration for the amount of cobalt present was obtained.

2. *Nickel.*—In the presence of nickel it was found impossible to employ the method without modification, unless the quantity of that metal was much less than that of the cobalt, as the coloration with α-nitroso-β-naphthol was considerably altered. Separation of the nickel by dimethylglyoxime enabled an accurate estimation of the cobalt to be made, provided the excess of the oxime was destroyed.

To the neutral or slightly acid solution a few cc. of ammonium citrate solution were added, and after dilution with water to about 100 cc. the liquid was heated nearly to boiling. A slight excess of a 1 per cent alcoholic solution of dimethylglyoxime was added (about 1 cc. for every 2 mgrms. of nickel), then ammonia, drop by drop, until the liquid was slightly alkaline. After stirring and allowing to stand for five minutes in a warm place, the precipitate was filtered off and washed with hot water. The clear filtrate was made up to a convenient bulk, an aliquot part transferred to a porcelain dish, evaporated to

* Read at the meeting of the Society of Public Analysts, June 5, 1918. From *The Analyst*, xliii., Sept., 1918.

dryness, and gently ignited. The residue was treated first with aqua regia, then with concentrated hydrochloric acid, and evaporated to dryness; after addition of a drop of dilute hydrochloric acid and extraction with hot water the cobalt was estimated in the usual way.

3. *Manganese.*—When the amount of manganese was very considerably greater than that of the cobalt it was found necessary to remove most of the former metal before proceeding to the estimation of the cobalt.

Several methods for the separation of the two metals were tried, and of these the most satisfactory was by means of sodium bismuthate and subsequent boiling to precipitate the manganese; the manganese was not wholly removed, but a sufficient separation was effected to enable the cobalt to be estimated.

To the solution containing the metals as chlorides there were added about an equal bulk of nitric acid (sp. gr. 1·2) and a small quantity of sodium bismuthate. It was then digested on a hot plate until the permanganate colour had disappeared and the manganese was precipitated; the precipitate was filtered off and the filtrate made up to a suitable bulk. An aliquot part of the solution was transferred to a Nessler cylinder, 5 cc. of a neutral ammonium citrate solution added, and the liquid was neutralised with ammonia, using litmus paper as indicator. Then a measured quantity of ammonium hydroxide (about 10 per cent NH_3) was added, and the colour was matched against standard cobalt solution, to which were added the same quantities of neutral ammonium citrate, ammonia, and a-nitroso-β naphthol as used with the sample.

The procedure in the case of zinc oxide paints was similar to that employed for varnishes—viz., incineration, to destroy organic matter, followed by digestion with concentrated hydrochloric acid and aqua regia if necessary. The excess of acid was removed as completely as possible by evaporation, and the residue dissolved and made up to a convenient bulk for colorimetric comparison.

The following results were obtained in two analyses:—

Per cent Co added.	Per cent Co found
0·063	0·063
0·114	0·103

The author desires to acknowledge his indebtedness to Mr. F. C. Guthrie, B.A., A.I.C., for valuable assistance in connection with this work.

WOLFRAM ORE AND TUNGSTEN.*

Tungsten is a metal of very high specific gravity and high melting-point. It is used to some extent for filaments of metallic lamps, and in large quantities as an alloy with steel. It has, even in comparatively small proportions, certain hardening and magnetic effects, and in large proportions, *i.e.*, from 12 per cent to 22 per cent, it has a peculiar property of giving a material for cutting tools which retains its hardness at high temperatures. The use of this material allows the speed of machines and depth of cutting to be increased far beyond what was possible with older forms of tool steel. Tool steel of this class has become an absolute necessity of modern engineering. When tungsten is mentioned in this report it refers both to tungsten powder and ferro-tungsten. Tungsten metal powder and ferro-tungsten are the basis of the manufacture of:—(1) High-speed steel; (2) magnet steel; (3) other tool steel containing tungsten. The percentage of tungsten used varies:—(*a*) in high-speed steel, 12 per cent to 22 per cent; (*b*) in magnet steel, 3 per cent to 6 per cent; (*c*) in other tool steel, 1 per cent to 10 per cent. The other uses in this country for tungsten are:—(1) Electric lamp filaments; (2) contacts for magnetos in place of platinum; (3) in the form of tungstate of soda for fire-proofing fabrics; (4) other minor uses.

The amount of high-speed and other tungsten steels now being manufactured in this country under war conditions is approximately 20,000 tons a year, which is being distributed as follows:—In England, 8000 tons; in Russia, 3500 tons; in the United States of America, 2500 tons; in Japan, 1000 tons; in Canada, 1000 tons; in France, 2000 tons; in Italy, 1000 tons; in Australia, New Zealand, and South Africa, 700 tons; to other Allies and necessary Neutrals, 300 tons, calling for about 3000 tons of metallic tungsten or its equivalent in ferro-tungsten.

In peace time the quantity of high-speed steel made by this country may be approximately taken at 40 per cent of the above amount. High-speed steel is used for:—(1) Engineers' tools, such as turning tools, planning and slotting tools; (2) twist drills, reamers, taps and screwing dies; (3) metal milling cutters, cold iron saws, and shell making tools; (4) valves in motor and aeroplane engines and magnetos.

The raw material from which metallic tungsten and ferro-tungsten are made is wolfram ore, alternatively described as wolframite or wolfram concentrates, which is mined largely in the British Empire.

A table given here indicates the chief sources of supply of wolfram concentrates and the average quantities shipped from the various countries in 1910, 1911, and 1912. Out of 8639 tons produced in 1912, approximately 3800 tons were produced in the British Empire. The production from Burma is increasing rapidly.

The world's figures for 1913 are not available in their complete form, but the figures of the British Empire since then up to 1915 are recorded at the Ministry of Munitions. The output from the British Empire for the year ending August 31, 1916, was 4600 tons. The Committee is informed that as the result of war conditions there has been an abnormal increase of the output of wolfram ore in the United States, where the amount for the six months, January 1 to June 30, 1916, is reported at 3750 tons. It requires practically 2¼ tons of wolfram concentrates to produce 1 ton of tungsten.

At the outbreak of the war no tungsten powder was being made in this country. At least three manufacturers were making ferro-tungsten on a small scale. The greater part of the wolfram ore produced appears to have passed through this country. The bulk of it found its way to Germany, where the manufacture of metallic tungsten powder was carried on chiefly in association with large chemical works from which the necessary supplies of hydrochloric acid and other chemicals could be obtained economically. The tungsten powder was then sold by Germany to this country, and was used by steel makers for the manufacture of high-speed steel, of which considerable quantities were exported to the United States, France, Germany, &c. Tungsten powder is also made in the United States of America and ferro-tungsten in France. There appears to have been no reason in the past, apart from organised German competition, including price cutting, why tungsten metal should not have been produced in this country. The value of the ore produced annually in the British Empire is estimated at £1,250,000; the value of the tungsten refined from this ore is estimated at £2,000,000, and the value of the high-speed and other steels made from this tungsten in the British Empire is estimated at £7,500,000, all at war prices. High-speed steel makers were content, before the war, to rely upon German supplies which were of satisfactory quality, and the trade, in spite of its importance, had not hitherto received full attention from English manufacturers. On the declaration of war the want of tungsten became immediately apparent. The manufacturers' stocks held here were practically three months' normal supply. The Admiralty took steps to ensure that all wolfram ore produced under the British flag was sent direct to this country. Reduction works were started, and there are now some eight or nine works in this country producing the require-

* Report of Departmental Committee on the Engineering Trades after the War. From the *Journal of the Royal Society of Arts*, lxvi., No. 3436.

ments of the trade. It would appear essential, from the point of view of national safety, that the Empire should not again run the risk of being without tungsten metal at a momentous crisis, or during normal times. The present British manufacturers of tungsten doubt their ability to continue in the trade after the war in competition with German manufacturers—though this is not the unanimous opinion of those now engaged in manufacturing. It is apparent that under the British flag there is likely to be sufficient supply of wolfram ore for British requirements.

In order to supply the high-speed steel which is necessary for the security of the nation in times of war, and for its prosperity in times of peace, it is necessary to provide tungsten in sufficient quantities, or its equivalent in ferro-tungsten. To do this two conditions are essential:—(1) Sufficient ore supplies; (2) works in the country capable of reducing the ore. As to the first condition, it appears that so large a proportion of the world's wolfram ore is produced in the British Empire that the object would be secured if British works had a first claim to the ore produced in the Empire. As to the second condition, sufficient works have been created in this country in the stress of war to meet all likely requirements, and if these works are maintained and kept efficient it appears only necessary to prevent the trade from being crushed by organised attacks by their competitors abroad, either by underselling or "cornering" ore supplies.

[The Committee suggests that the Dominions and *Dependencies should be communicated with at once, and* their views ascertained as to the following proposal made to carry out effectually the conclusions to which the Committee has unanimously agreed, namely, that all wolfram ore or other ores containing wolfram, pay a penalty in a form analogous to an export duty on leaving the Empire of £25 per ton.]

As regards tungsten (tungsten powder and ferro-tungsten), the Committee's conclusions are:—(1) It is essential that tungsten should be manufactured within the Empire in such quantities that the normal demands should be easily met, and a sufficient supply for export manufactured, so that in case of an abnormal demand for defensive or other purposes, an adequate supply shall be available within the Empire: (2) that the works manufacturing tungsten which have come into existence, either at the request of the Government or otherwise during the war, shall receive subsidies or special consideration as regards Excess Profits Tax in relation to the amount of money they have sunk in the industry, either by way of wolfram ore dressing plant, tungsten producing works, research work, mines, or concessions for the raising of wolfram ore, and generally with a view to meeting German competition after the war.

NOTICES OF BOOKS.

Rubber: Its Production, Chemistry, and Synthesis in the Light of Recent Research. By A. Dubosc and Dr. N. Luttringer. English Edition by Edward W. Lewis, A.C.G.I., F.C.S. London: Charles Griffin and Co., Ltd. 1918. Pp. xi+383. Price 21s. net.

Although five years have passed since the French original of this book appeared the text can in hardly any way be regarded as out of date, for in that period comparatively little research work has been done on the chemistry of rubber. There was undoubtedly room for authoritative text-book dealing with the chemistry of raw rubber, and this book has supplied the need which chemists were feeling for a comprehensive survey of all the work that has been done, especially on the synthetic production of rubber. The authors' experience and knowledge have enabled them to make valuable criticisms of the many processes which have been put forward, and no worker in this region will in the future be able to do without this text-book, which is characterised by an admirably judicious and unbiased treatment of the problems of rubber chemistry. The first section deals with the production of natural rubber, the costs of production and the utilisation of reclaimed rubber. The data and statistics are here unavoidably somewhat behind the times, but the translator has brought them up to date in some cases. The problem of the utilisation of raw rubber is admitted to be as yet unsolved. In Part II. the method of formation of rubber in the plant is discussed, and the physical properties are described with great completeness. Methods of analysis and researches on the constitution of rubber are fully treated, thus leading up to the third and last section in which an exhaustive account is given of all the work which has been done on the problem of the synthetic production of rubber. Methods of preparing isoprene and its homologues are first discussed very fully, and the authors demonstrate clearly the superiority of the "English" over the lengthy and expensive German process. Finally, the preparation of synthetic rubber is treated in the last chapter, and it is pointed out in conclusion that the synthetic product from isoprene appears to be identical with natural caoutchouc, while the substance obtained from butadiene and dimethylbutadiene is evidently different from the natural product.

Dyeing and Cleaning. By Frank J. Farrell, M.Sc. (Vict.). Fourth Edition. London: Charles Griffin and Co., Ltd. 1917. Pp. x+253. Price 6s. net.

The technology of the textile fibres is briefly treated in an introductory chapter in this book, which will be found a very useful and practical handbook by the dyer and cleaner. Methods of dry and wet cleaning are treated in considerable detail, and students as well as those actively engaged in the industry will find it a reliable and comprehensive guide, and the sections on such subjects as the removal of different kinds of stains will be of great practical utility. In the chapters on dyeing the special problems and difficulties of the job dyer as distinguished from the piece dyer of new goods are discussed, and full accounts are given of the procedure to be adopted in the cases of all kinds of garments made of different materials or combinations of materials. Lists are given of many different dyestuffs from which a selection can readily be made for specified purposes, and one chapter is devoted to the description of methods of finishing various kinds of goods. The fourth edition of the book has undergone a considerable amount of revision, especially in the part dealing with dyeing. The author now refers only to dyes of British or "neutral" origin, and the book well illustrates our independence of German dyeworks and their products.

American Lubricants. By L. B. Lockhart. Easton, Pa.: The Chemical Publishing Co. London: Williams and Norgate. Tokyo: Maruzen Co., Ltd. 1918. Pp. ix+236.

This book will have its value to English users of lubricants, although the products obtainable and used in America differ somewhat from ours. It is intended to be more particularly useful to the user and consumer, and a deeper and more scientific knowledge of the nature and properties of different lubricants might certainly lead to the avoidance of waste and loss. It was perhaps hardly necessary to include the preliminary part of the book dealing with crude petroleum, its origin, methods of refining, &c., but the later parts are thoroughly practical and it would require some searching among all kinds of periodicals and books to find some of the information given, which is very systematically and conveniently arranged. The special problems of many different kinds of machinery are considered in detail, and the lubricants suitable for use in various circumstances are discussed. Methods of testing lubricating oils and greases are included, and seven chapters are given to specifications for different kinds of oils, greasers, &c.

CORRESPONDENCE.

ELEMENTS IN THE ORDER OF THEIR ATOMIC WEIGHTS.

To the Editor of the Chemical News.

SIR,—In arranging the elements in the order of their atomic weights I noticed a peculiar sequence which repeated itself so often as to appear to be more than mere coincidence.

Although a student of chemistry, I am ignorant as to whether the data given herewith are known to exist, or, if unknown, whether it possesses any particular value.

The following is the scheme of the sequence:—Assuming the first weight to be X, the second number would be X+3, the third X+3+1, the fourth X+3+1+3, and so on, adding 1 and 3 alternately.

In the table herewith but 17 of the 83 elements do not coincide with what I termed "Theoretical weight." Three of the 17, Gd, Ta, and Yb, were listed as 156, 183, and 172 respectively in International Atomic Weight Tables several years past. If these weights were unchanged, they too would have a place in the accompanying table. If by chance our present weights for Rb, Cb, and Ru were only equivalents and their true atomic weight twice the equivalent, they also would fit in the "Theoretical" column.

Theoretical.	Symbol.	Oxygen = 16.	Omissions.	
1	H	1·008		
3				
4	He	4·00		
7	Li	6·94		
8			Gl	9·1
11	B	11·0		
12	C	12·0		
15			N	14·01
16	O	16·0		
19	F	19·0		
20	Ne	20·2		
23	Na	23·0		
24	Mg	24·32		
27	Al	27·1		
28	Si	28·3		
31	P	31·04		
32	S	32·06		
35	Cl	35·46		
36			A	39·88
39	K	39·10		
40	Ca	40·07		
43				
44	Sc	44·1		
47				
48	Ti	48·1		
51	V	51·0		
52	Cr	52·0		
55	Mn	54·93		
56	Fe	55·84		
59	Co	58·97	Ni	58·68
60				
63	Cu	63·57		
64			Zn	65·37
67				
68			Ga	69·9
71				
72	Ge	72·5		
75	As	74·96		
76				
79	Se	79·2		
80	Br	79·92		
83	Kr	82·92		
84			Rb	85·45
87	Sr	87·63		
88	Yt	88·7		
91	Zr	90·6		
92			Cb	93·1
95				
96	Mo	96·0		
99				
100			Ru	101·7
103	Rh	102·9		
104				
107	Pd	106·7		
108	Ag	107·88		
111				
112	Cd	112·4		
115	In	114·8		
116				
119	Sn	118·7		
120	Sb	120·2		
123				
124				
127	I	126·92		
128	Te	127·5		
131	Xe	130·2		
132	Cs	132·81		
135				
136			Ba	137·37
139	La	139·0		
140	Ce	140·25		
143			Pr	140·9
144	Nd	144·3		
147				
148				
151	Sm	150·4		
152	Eu	152·0		
155				
156			Gd	157·3
159	Tb	159·2		
160				
163	Dy	162·5		
164	Ho	163·5		
167	Er	167·7		
168	Tm	168·5		
171				
172			Yb	173·5
175	Lu	175·0		
176				
179				
180				
183			Ta	181·5
184	W	184·0		
187				
188				
191	Os	190·9		
192			Ir	193·1
195	Pt	195·2		
196			Au	197·2
199				
200	Hg	200·6		
203				
204	Tl	204·0		
207	Pb	207·2		
208	Bi	208·0		
211				
212				
215				
216				
219				
220				
223	Nt	222·4		
224				
227			Ra	225·0
228				
231				
232	Th	232·4		
235				
236				
239	U	238·2		
240				

There are also blanks on my chart where no known elements fall, and if the regular sequence is authentic a hypothetical element would exist for each atomic weight not already filled.

The weights given in the accompanying table are taken from the International Atomic Weight Table for 1918, with oxygen = 16.—I am, &c.,

Raymond Szymanowitz.

130, Sherman Avenue, Newark, N.J., U.S.A.

PEAT.

To the Editor of the Chemical News.

Sir,—Power-producing fuel is vital to industries, and I venture to suggest that we have hitherto neglected a plentiful supply of it—peat. Much has been done towards extracting alcohol or ammonia from peat by saponification or decomposition with acids, but as a source of industrial energy it has been forgotten throughout the British Empire. The process by which peat could be made profitable is that of reversed distillation. The peat may be gasified after the usual method of dry distillation, or may be actually burned in a combustion-chamber, and the resulting gases passed through red hot peat charcoal, the residue of previous distillation. The useless carbon dioxide and water contained in the gases resulting from the combustion are reduced by the carbon to carbon monoxide and methane, and a complex gas of high calorific value is obtained. The process was invented by a chemist of the name of H. Riche, and has been in use in France. The application of power is a question for the engineer, but the indication of it comes within the province of the chemist; therefore I venture to suggest that peat is a large and hitherto practically untouched source of industrial energy.—I am, &c.,

Lillian Chapman.

15, Carlyle Mansions, Cheyne Walk.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Note.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxvii., No. 1, July 1, 1918.

Combinations of Neutral Zirconyl Sulphate with some Alkaline Sulphates.—Ed. Chauvenet and H. Gueylard.—Thermochemical measurements indicate the existence of the two compounds, $[ZrO.SO_4]_3.2Na_2SO_4$ and $[ZrO.SO_4]_3.2(NH_4)_2SO_4$, as well as two hydrates containing seven molecules of water. Compounds of the type $[ZrOSO_4]_2X$, where X is ZrO_2 or an alkaline sulphate, are also known. The authors propose to investigate whether X can be a molecule of chloride, phosphate, tartrate, or oxalate.

Presence of a Non-volatile Alkaloid in the Broom (*Sarothamnus scoparius*). Amand Valeur.—When sparteine is extracted from broom, from the last mother-liquors two new alkaloids have been isolated, one non-volatile and the other volatile. The former has been investigated by the author, and the name sarothamnine suggested for it. Its formula appears to be $C_{15}H_{24}N_2$, and thus it possesses two atoms of hydrogen less than sparteine, and is isomeric with spartyrine, obtained by gentle oxidation of sparteine. Sarothamnine has a remarkable power of combining with certain solvents, giving crystallised compounds with, for example, methyl alcohol and benzene. It is an unsaturated base. It is possible that the base does not exist as such in broom, but results from the decomposition or transformation of another alkaloid, possibly oxygenated.

No. 2, July 8, 1918.

This number contains no chemical matter.

No. 3, July 16, 1918.

Combinations of Acid Zirconyl Sulphate with some Alkaline Sulphates.—Ed. Chauvenet and H. Gueylard.—Cryoscopic and thermochemical measurements have proved the existence of compounds of acid zirconyl sulphate with ammonium and sodium sulphates, and by thermochemical measurements the authors have been enabled to obtain the compounds in the solid state and also to find compounds the existence of which in solution is uncertain.

New Method of Rapid Destruction of Organic Materials.—Paul Duret.—This method is based upon the production in the nascent state of strongly ozonised oxygen, by means of ammonium persulphate in an acid medium. The manipulation is easy and simple and no special apparatus is used; no nitrous or chlorine fumes are evolved. The method is, moreover, rapid and accurate, and the organic matter is completely oxidised without loss.

No. 4, July 22, 1918.

Acid Function of Osmium Tetroxide.—L. Tschugaeff.—Osmium tetroxide is generally supposed to possess no acid properties, but the author has found that this is not the case. He has obtained a series of well-defined compounds of it with the hydroxides of potassium, cæsium, and rubidium of general formula $2MOH.OsO_4$. They are crystalline orange or brown compounds, very soluble in water, the aqueous solutions being strongly *hydrolysed*. The cæsium compound is the least soluble and very readily separates when a very concentrated solution of cæsium hydroxide is added to a saturated solution of osmium tetroxide.

New Volatile Alkaloid from Broom.—Amand Valeur.—The author has recently shown that from the mother-liquors obtained in the crystallisation of commercial sparteine sulphate a new non-volatile alkaloid, sarothamnine, can be separated. If after the separation of these bases soda is added to the liquor a new volatile alkaloid is obtained. The author suggests for it the name "genisteine." Its formula is $C_{16}H_{28}N_2$. It absorbs water vapour very readily, giving a hydrate which can be obtained in the form of voluminous crystals. Genisteine behaves like a monacid base towards phthalein, but it is really diacid, as shown by its picrate and chloroplatinate, the formulæ of which are $C_{16}H_{28}N_2.2C_6H_2(NO_2)_3OH$ and $C_{16}H_{28}N_2.2HCl.PtCl_4 + 2{\cdot}5H_2O$ respectively. The base is lævorotatory, saturated, and not methylated at the nitrogen atom. It is remarkable that the boiling-point of genisteine is a little lower than that of sparteine, although it possesses a CH_2 more.

No. 5, *July* 29, 1918.

Zirconium Nitride.—P. Bruère and Ed. Chauvenet.—When the ammonia compound of zirconium chloride, $ZrCl_4.4NH_3$, is heated, the amide, $Zr(NH_2)_4$, is first formed. On further heating the imide, mixed with some nitride, is obtained, and finally at about 350° the imide is completely decomposed, and the pure nitride, Zr_3N_4, is formed. Probably this is the only nitride of zirconium, and the two others which have been described, Zr_2N_3 and Zr_3N_8, do not exist.

No. 6, August 5, 1918.

New Reaction of Osmium.—L. Tschugaeff.—If a solution containing osmium in the state of tetroxide, or any chloroosmiate, is heated for some minutes with excess of thiourea and some drops of hydrochloric acid, the liquid turns dark red or pink according to the concentration of the osmic solution. Analysis shows that the red compound formed has the formula $[Os6(NH_2.CS.NH_2)]Cl_3H_2O$, and is thus the derivative of a new base analogous to the luteo-chromic, cobaltic, rhodic, and iridic salts.

MISCELLANEOUS.

Society of Public Analysts.—The next meeting of the Society will be held on Wednesday, November 6, at the Chemical Society's Rooms, Burlington House, Piccadilly, W., at 5 p.m. The following papers will be read:—"Note on the Graduation of Gerber Butyrometers," by H. Droop Richmond, F.I.C. "The Estimation of Cacao Shell," by Basil G. McLellan, F.I.C., and Arthur W. Knapp, B.Sc., F.I.C.

The Ceramic Society.—The opening of the Solon Library, in co-operation with the Governors of the Central School of Science and Technology, will take place on Thursday, November 14, 1918. An Address will be delivered by Sir Henry Cunynghame, C.B., at the Central School of Science, Victoria Road, Stoke. The Chair will be taken at 7.30 p.m., by the President of the Society (Mr. R. Lewis Johnson), and a cordial invitation is extended to all interested.

Institute of Chemistry.—The Manchester Local Section of the Institute of Chemistry was formed at a well-attended meeting held in the rooms of the Chemical Club at the Victoria Hotel, on Friday, October 4, Mr. J. H. Lester, the Chairman of the Provisional Local Section, presiding. The Registrar of the Institute was also present. The meeting discussed the Draft Rules for Local Sections and a new scheme for the election of the Council of the Institute. Votes were taken on several matters which will be brought to the notice of the Council. The Committee of the Provisional Section, with the addition of Mr. W. D. Rogers, who had been acting as Honorary Secretary, was elected as the Committee of the Section. Mr. David Cardwell was appointed Secretary on the retirement of Mr. W. D. Rogers, to whom a vote of thanks was accorded for his services.

Basic Carbonates of Copper.—Horace Barratt Dunnicliff and Sudarshan Lal.—The authors have analysed many specimens of commercial copper carbonate and find that the statement that it has the same composition as malachite is incorrect, and that in reality it is a mixture of very varying composition. An attempt was made to prepare a basic copper carbonate of approximately constant composition from pure materials, and a new carbonate, $2CuCO_3.5Cu(OH)_2$ was prepared.—*Journal of the Chemical Society*, Sept., 1918, p. 718.

The Uses of Tungsten.—An important application of tungsten is for the production of tungsten steel employed in the construction of magnets for aeroplane magnetos and high-speed tools. A less known but equally important application of tungsten, illustrated at the "Key" Industries Exhibition at the Central Hall, Westminster, is as a substitute for platinum and its alloys. In wireless telegraph instruments, magnetos, and various electrical appliances, tungsten parts are used at one-tenth the cost of platinum with even better technical results. Combined with sodium, tungsten compounds are largely employed for impregnating fibres to render them fireproof, and as a mordant in dyeing. Public interest in the "Key" Industries Exhibition shows no sign of falling off, the attendance so far averaging about 4000 daily.

Problems of Metallurgy.—The importance of education in relation to the future of metallurgical industries was emphasised at the opening meeting of the winter session of the Birmingham Metallurgical Society. The President (Mr. Isaac E. Lester) said we had to study the effect of the war on the metallurgical industry. It was of the highest importance that manufacturers should be fully equipped not only in the ferrous but in the non-ferrous and allied industries. The practical man in the works should have every facility to study the principles of pure science, and the scientist should have recourse to works practice. Every town or city of metallurgical importance should have its own central bureau of scientific information, with a fully equipped analytical chemists' laboratory, library, and museum, and with a common arena for qualified entrants; or the university should be the one central body and also the research rendezvous for scientific thinkers and workers. It was the duty of capitalists, economists, employers, and employees to demand the establishment of the necessary means of technical education and scientific research.

Some Properties of Metals under the Influence of α-Rays.—When α-rays strike an insulated metal surface in a high vacuum the metal becomes positively charged. This charge is due to two chief causes—(i.) the positive charge carried to it by the α particles; (ii.) the negative charge carried away by the electrons emitted, these emitted electrons being known as δ rays. The speed of the δ ray electrons varies very much, but all the metals which have been investigated give practically identical ionisation curves, and this result has led to the supposition that the entire δ-ray effect is not a metallic ionisation at all, but is due to a film of gas adsorbed into the surface of the metal. Mr A. G. McGougan has arranged a series of experiments to investigate this question, and has studied the effect of scraping the surface of the metal while in a high vacuum, so that a fresh clean surface was presented to the bombardment of the α rays. This led to a varying reduction in the δ-ray current, which, however, was not permanent. The δ-ray emission from a mercury surface was not affected by overflowing the surface. The evidence in these experiments supports the belief that the δ-ray effect in metals is due to a gas film on the surface, while in the case of mercury the film is formed from molecules of gas contained within the liquid.—*The Physical Review*, No. 2, xii., 122.

Engineering Investigation in Brazil.—The Government, through the Department of Overseas Trade, are embarking upon another investigation abroad; this time they have agreed to share the cost with the British Engineers' Association of an investigation into the prospects for the engineering industry in Brazil. The Investigator, whose name will be announced very shortly, will spend probably twelve months in Brazil, and his reports will cover the whole field open to engineering enterprise. In carrying out this investigation we understand that the Council of the Association is not animated by any hostility towards the merchants and other existing channels through which engineering business has been carried on. They are desirous solely of obtaining for their members information of the requirements of the Brazilian market, the openings for engineering plant and machinery, and particulars of the methods of doing business most likely to suit possible purchasers and users. It will be open to members who receive these reports to do business in any way they like. Some members of the Association are already established in Brazil with branch houses, others already do business through the merchanting and importing houses. Therefore one result of this investigation should be to make manufacturers more willing to adapt their products and methods to local interests and in this way this investigation should make it easier for merchants to supply their Brazilian demands from British sources. Now that this first investigation is settled the Council of the British Engineers' Association hope to arrange for similar investigations in other countries. Manufacturing engineers not members of the Association who desire to take advantage of the reports of the Investigator should communicate with the Secretary, The British Engineers' Association, 32, Victoria Street, London, S.W. 1.

Royal Photographic Society of Great Britain.—This Society is holding its 63rd Annual Exhibition of Photographs on its own premises at 35, Russell Square, and invites the public to view the collection free of charge. The Exhibition will be open daily (Sundays excepted) from 11 a.m. till 9 p.m., till November 30, and lantern lectures on popular and interesting subjects will be delivered each Tuesday and Friday evening from 7 till

8 30 o'clock. A collection of Official War Photographs supplied by the Ministry of Information will appeal to all, whether interested in photography or not. These unique representations of the Army's work at the front are displayed on the walls of the Society's library and comprise the most varied subjects. Tanks in action, bursting shells, prisoners emerging from their "dug-out," German "pill boxes," the rescue of a blind woman from a ruined house, and, rarest of all incidents, an official jest, for in the description of a pile of empty shell cases it is stated that the contents have been delivered to the Germans. The Pictorial Section is hung in the Meeting Room and is particularly rich in portraiture and figure study, in addition to the landscape and other subjects which exhibit considerable merit. Scientific and technical subjects will be found in the Council Room and the adjacent Committee Room; X-ray work, natural history, photo-micrography, astronomy, and the application of photography to special purposes are included. In the Committee Room are also stereoscopic and other transparencies, a large number of these latter being colour pictures by the ever popular Autochrome and Paget processes. In the Library Extension Room is a series of transparencies particularly interesting to medical men, as the items illustrate the control that may he exercised over the X-ray plate. These transparencies will be changed weekly. Medals have been awarded by the Judges to H. Essenhigh Corke, Profs A. Fowler and R. J. Strutt, Dr. R. Knox, Louis J. Steele, and Hugo van Wadenoyen.

TO comply with Regulation 8 (b) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Assistant Chemist required by large Engineering Works. Knowledge of Gas, Fuel, and Water Analysis essential Apply, stating age, training, and salary required, to your nearest Employment Exchange, quoting No A 6117. No one at present engaged on Government work need apply.

ANALYTICAL LABORATORY.—Assistants wanted; must be conversant with Volumetric Work and preferably have knowledge of Pharmacy. £90 to £130.—Address, Box 661, Smith's Agency, Ltd., 100, Fleet Street, E C. 4.

Chemist, twenty-seven years' experience in Iron and Steel Works' Analysis, requires Post. Aged 44.—Address, William Graham, 34, Cimla Road, Neath, Glamorganshire.

CHEMICAL ASSISTANT.—Well qualified Junior wanted in the Laboratory of a Manufacturing business in Limehouse. State salary and give references.—Address, "Limehouse," Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

INDIA.—Chemical Engineer wanted with B.Sc or equivalent degree; unmarried, ineligible, or discharged. —Address, D. W., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C 4.

Lady Assistant Chemist required (for Analytical and Research Work) by a Controlled Firm in the Midlands. Must have had a sound training in Theoretical and Practical Inorganic Chemistry. Good salary offered to suitable applicant. State, age, qualifications, and experience.—Address, L S, Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Men or Women Chemists, with University training or its equivalent, wanted in one of Curtis's and Harvey's Explosive Factories in Kent.—Apply, Box 778, care of Leathwait and Simmons, 5, Birchin Lane, E.C 3.

Research Chemist wanted. Knowledge of Organic Chemistry and experience in General Metallurgical Analysis essential. No one at present engaged on Government work need apply.—Apply, stating age, experience, and salary required, to your nearest Employment Exchange, quoting No. A 6131.

Research Chemists wanted, with good knowledge of Physical and Electro chemistry. Salary, £200 to £350 according to qualifications and experience.—Apply to the Salt Union, Ltd., Weston Point, Runcorn.

Wanted, Assistant Chemist with experience in the analysis of Iron, Steel, and Non-ferrous Alloys, for large Works in the North of England. No one at present engaged on Government work need apply.—Write, stating age, experience, and wages required to nearest Employment Exchange, quoting No. A 6182.

Works Chemist wanted, with experience suitable for manufacture of Fine Chemicals. Position would be permanent and progressive for suitable man. State experience, references, and terms.—Address, F. C., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Works Analytical Chemist required. One conversant with Soap Manufacture, Nicotine Extractions, and Agricultural and Horticultural Preparations. State full particulars and salary required.—Address, W. A., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

TO ASSAYERS.—Double purchase FLATTING MILL, Steel Rolls. On legs for fixing to floor. £17.—Daw 136, Westcombe Hill, Blackheath, S.E.

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D. J. A. BROWN, Registrar.

University College, Cathays Park, Cardiff,
October 14, 1918.

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THE CHEMICAL NEWS

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SPECIAL NOTICE TO SUBSCRIBERS.

THE recent paper restrictions have compelled us to publish only fortnightly instead of weekly for a time, but we are now glad to be able to announce that we are to be allowed a further supply of paper, which will enable us to revert to weekly publication in the near future.

Beginning with No. 3064, to be published on January 3, 1919, the CHEMICAL NEWS will again appear weekly, and the dates of expiration of subscriptions will be adjusted accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their subscription periods. The price will remain unaltered, viz., £1 for fifty-two numbers, or *pro rata*.

THE NATIONAL ASPECTS OF CHEMISTRY.*

By WILLIAM JACKSON POPE, M.A., D.Sc., LL.D., F.R.S.,
Professor of Chemistry in the University of Cambridge,
and President of the Chemical Society.

DURING the past three or four years it has been unusual to peruse any British newspaper without meeting with some remark indicative of the writer's conviction that the more intensive cultivation of chemistry is essential to the national well-being. For the half century previous to 1914 every chemist of distinction in our country had seized every available opportunity of insisting that the national neglect of chemistry, and, indeed, of natural science in general, was leading the nation into difficulties; in the main, the declamations of Roscoe, Armstrong, Meldola, and many others whose names are household words in the chemical world, fell upon deaf ears.

Some attempt should be made to explain the rapid change of public opinion with regard to chemistry which set in with the autumn of 1914; we require to understand clearly how neglect of any scientific subject could so suddenly give place to absolute worship.

The reason is one which will be readily appreciated. For the past century chemistry has been a favourite subject of study in this country, and many of the mile-stones in the rapid advance of this branch of experimental science have been placed by British chemists; many of the important chemical industries were established in England and flourished until State-aided foreign competition caused their transference abroad. Public interest was never awakened to the national importance of conserving these British industries, and they consequently languished as a result of greater administrative astuteness exhibited on the Continent. At the commencement of the war our chemical industries had declined to such an extent that Great Britain was dependent on German chemical industry for materials essential to practically every large manufacturing operation.

The sudden check upon German chemical imports into this country led to the embarrassment of all productive enterprise in Great Britain. The stoppage of German coal tar dyes worth about £2,000,000 per annum, checked a turnover of £200,000,000 per annum in textiles to such an extent that the production of khaki woollens for the troops was endangered, natural and artificial pharmaceutical products, such as quinine, salicylic acid, and antipyrine, mostly controlled or produced by Germany, rose to phenomenal prices; alloys necessary in the manufacture of steel for high-speed tool and armour plate, again largely of German origin, were difficult to obtain. Hundreds of other instances might be quoted to show the inhibitive effect produced upon industries representing an annual turnover of a thousand million pounds by the impossibility of obtaining a few million pounds worth per annum of necessary materials.

We know now that these results were not fortuitous; they eventuated from a carefully-planned and splendidly executed scheme for seconding military effort by economic preparation; a nation embarrassed in its industries is necessarily weakened both in defence and offence.

The tardy realisation of the fact that Great Britain had been brought to the verge of ruin by her neglect of applied science has been a great stimulus to public interest; probably it is not even yet understood that the neglect of pure science is at least as much responsible for the imminence of disaster.

The few examples just quoted will probably suffice to indicate that the science of chemistry really possesses national aspects, and that these are not unimportant as economic factors. In order to accentuate this point it will be useful to outline briefly the history of one or two important advances in technical science.

The metal tungsten was prepared by three Spanish chemists in 1783. About sixty years ago a firm of Sheffield steel manufacturers discovered that the addition of tungsten to steel results in the production of an alloy of great value as a high-speed cutting tool material. At that time the manufacture of metallic tungsten had been but imperfectly studied, but during later years the German metallurgical chemists succeeded in manufacturing tungsten at such a cost that its use in high speed steel became practicable; a monopoly of the supply of tungsten to Sheffield was thus established by Germany. Although one-half of the world's production of tungsten ore is mined within the British Empire its smelting was entirely in German hands; all the tungsten ore produced in the Empire was worked up by German metallurgical firms and the produced tungsten sold by Germany to the Sheffield steel-makers who had first actually invented tungsten-steel. At the outbreak of war the shortage of tungsten stocks in this country led to a Government inquiry, and, in the end, the manufacture of tungsten was installed in Great Britain with such success that the English smelted metal is now being supplied to the steel-makers in a higher state of purity and at a lower price than the German product. It is worthy of note that but little tungsten is mined in Germany; a small output is obtained from the Saxony mines, and the only adjacent non-enemy sources are in Spain and Portugal. It is also noteworthy that whilst no German technologist or chemist made any strikingly novel contribution to the development of the tungsten-steel industry, whilst no important source of the raw material lay in German territory, the major portion of the profits derived from this modern industry fell into German hands.

The manufacture of steel was a highly developed industry in Great Britain long before Germany had secured any production, and another illuminating case of the national importance possessed by a purely chemical industry is found in the history of German steel production. The scientific study of steel was initiated in this country by Sorby, of Sheffield; the microscopical methods of examining metallic alloys introduced by Sorby were developed by English metallurgists, such as Roberts-Austen, Stead and Arnold, and Heycock and Neville, long before any German metallurgist worked upon them

* A Lecture to Teachers given at the Regent Street Polytechnic on Saturday, October 12, 1918, under the auspices of the London County Council Education Department.

the later developments of these methods of examination has shown their results capable of interpretation in the light of the modern doctrine of equilibrium as first enunciated by the American chemist, Willard Gibbs.

The German Empire is poor in iron ores, and all which possess any importance are found on her frontiers. The Lorraine district annexed by Germany in 1871 contains an iron-ore reserve of about 1,800,000,000 tons and yields about three-quarters of the whole German steel output. The adjacent French territory, temporarily in German hands, has an ore reserve of about 3,000,000,000 tons of appreciably richer materials. A mistake was apparently made by Bismarck in his demands for territory after the Franco-German war by which, as transpired with the rapid development of metallurgical science, he left the most valuable of the iron deposits of Lorraine in French hands; just before the present war the French and German outputs of iron from the Alsace-Lorraine region were roughly equal. The ore from this district is a brown hæmatite very rich in phosphates; since the war of 1870 an economical process for treating these ores has been developed which yields as a by-product a basic slag which is of great value as a manure because of its high phosphorus content. When the Alsace-Lorraine iron fields are returned to France, Germany will be deprived of her main source of raw material for the manufacture of iron and steel. There are, however, in the Ukraine enormous deposits of a limonite which is very suitable for the manufacture of a high-grade Bessemer steel; this fact is, perhaps, not unconnected with German action upon her Eastern fighting lines.

One more instance of the important bearing of chemical science upon national concerns may be given before an attempt is made to draw the obvious conclusions. Round about Stassfurt, in Central Prussia, lies the dried-up residue of a vast pre-historic ocean. Each separate material, sodium chloride, potash and magnesium salts, salts of bromine and iodine, which can be obtained by the evaporation of sea-water, is here found in a solid bed and can be readily mined. Of these components, the potash salts are the most valuable. During many years past potash salts have been used in constantly increasing quantities as agricultural manure; during the years which lie in the near future still larger quantities of potash salts must be thus used in order to aid the intensive cultivation of the soil which will be necessary to feed the world. Stassfurt potash was first put on the market in 1861, and, by its low cost, quickly displaced the potassium salts obtained from other sources.

It is interesting to notice that the territory ceded by France to Germany in 1871 contains a series of deposits very similar to those in the Stassfurt district; about one-tenth of the German potash was indeed mined in Alsace before the war, and this output has since been materially increased.

For a number of years past Germany has produced potassium salts roughly equivalent to one million tons of potash per annum, and of this production 90 to 95 per cent is used as manure. In 1913 about one-half of the output was exported, but in 1917 only about one-seventh of the production was exported, the six-sevenths being used to replace previously imported manures such as phosphates and nitrates. The shortage of potassium salts outside Germany has been much felt during the last four years, and many attempts to provide the missing material have been made; one very promising of these is to be found in the separation of potash salts from the iron blast-furnace flue gases. This source of potash salts has been carefully examined by Mr. Kenneth Chance, and it seems clear that the agricultural needs of the country can be met by its utilisation. England imported about 23,000 tons of potash salts per annum from Germany before the war; France consumed about 90,000 tons per annum, and it is estimated that the French production of potash salts will this year mount to only 5000 tons.

Other considerable sources of potassium salts are known. Thus, in the purification by crystallisation of the 3,000,000 tons of Chili saltpetre extracted per annum, about 300,000 tons of potash are extracted, a quantity which would go far towards making up the deficit on German exports. Hitherto, however, this source of potassium salts has not been exploited technically; it has probably been carefully watched and held in check by the certainty of under-cost competition.

Other valuable constituents of the Stassfurt and Alsace salt deposits are iodine and bromine; here again no other source of these elements has been allowed to compete.

The consideration of the manner in which important raw materials, of which iron, tungsten-steel, potash, iodine, and bromine are but a few, have been dealt with by Germany leads us to draw one important conclusion with absolute certainty. There have existed for many years in Germany bodies composed of men of wide expert knowledge concerning the economics of raw materials whose advice on chemical production is received and acted upon by the higher political and military authorities. The uniform intelligence with which practically the whole world's production of raw materials has been transferred to German hands, the wide-spread and far-reaching ramifications of the pre-war German control of essential mineral and vegetable products, have been exhibited upon so vast a scale that they cannot be attributed to the mere commercial enterprise of individual business concerns ununified by Government aid. Germany has long had a definite policy for dealing with the raw materials produced within the British Empire; Great Britain has had none.

In this connection it would seem necessary to introduce the idea of a new sub-division of knowledge. The earth provides us with vast numbers and quantities of direct products which serve as the raw material for our great industries; these products are, of course, not uniformly distributed but are derived in quantities and qualities determined by the geographic and climatic conditions prevailing in any part of the world. The study of chemical geography would seem to be of prime importance to such an Empire as ours, in one corner or another of which is to be found in paying quantities practically every raw material for which mankind has found a use. The study of chemical geography at once makes clear that if Germany loses control of the coal, iron, and potash deposits on the West, and of the Galician oil wells on the East, and is deprived of the handling of the raw materials produced abroad, the German Empire falls automatically into the position of a fourth-rate power.

Similarly, the chemical geography of Central Africa indicates that the importance of that region lies less in its mineral wealth than in its potentialities as a producer of food-stuffs and primarily of vegetable fats. At present a world shortage of fats exists, and European requirements for food purposes can only be met in the future by importation from Africa. The loss of the German Colonies in Africa is very significant in this connection.

An illuminating article on the difficulties of the German situation with regard to edible fats appeared in one of the German technical journals of August last from the pen of Dr. W. A. Dyes. This gentleman spent many years in Manchester as a consulting chemist, and after being interned in this country until the end of 1915 was allowed to return to Germany. His wide knowledge of the chemical industries of this country and America has certainly been used to the material advantage of his country since his return home. In the article in question Dyes comments on the fact that the English production of margarine has risen from 88,000 tons in 1907 to about 240,000 tons in 1915, these figures being available before he quitted our shores, and remarks ruefully that the British Empire produces four-fifths of the world's output of palm and coconut oil. He doubts whether it will be worth while for Germany to attempt to bring her lost Colonies into oil production after the war, and is only

able to suggest that more intense efforts should be made to cultivate oil-bearing plants in Germany itself.

The attempt has been made above to show how an intimate acquaintance with the sources of supply of countless chemical raw materials, and an intelligent Government policy in connection with those sources of supply, acting through business and technical hands, has enabled an enemy power to gradually obtain the main control of British raw materials; many other instances of the same kind are known to readers of the daily press. If it is so essential to Germany, in view of her comparative poverty in essential raw materials, to possess this knowledge and to be able to wield this power, does it not seem far more necessary that Great Britain should command a Department fully alive to all the productive possibilities of the Empire; a Department, in fact, which should be the authority upon the chemical geography of the Empire.

During the past four years we have had a very hard struggle to hurriedly ensure the supply of essential raw materials which actually occur in predominant quantity in this country and her colonies; conspicuous as the success has been yet it has not been complete.

The statement has been made repeatedly that, vast as our Empire is, it is lacking in certain essential raw materials; this statement is of doubtful accuracy, but it must be conceded that a few necessaries are not produced at present within the Empire. Our poverty in potash is often instanced as a striking example of this lack. Quite recently a well known German authority published the following statement:—"The potash monopoly is an important weapon in the economic war which the Entente intends to carry on against Germany; potash will be of great importance in bringing German currency to a normal footing." We have already seen that ample potash deposits occur in territory which will soon be again in French hands, and that very satisfactory progress has been made in the production of potash salts from blast-furnace gases; other sources of this valuable manurial agent are being rapidly exploited in Europe and America, and, although it is not yet known whether these can compete economically with German or Alsacian potash, it is at least clear that they will suffice in any time of shortage. Our Empire is said to be lacking in bromine, of which the chief source in past years has been the Stassfurt deposits. Bromine was separated in 1826 by the French chemist Balard from sea-water, and at present France is producing about 500 tons per annum largely from the residual mother-liquors obtained by the evaporation of sea-water in the south of France; her pre-war annual consumption was about 300 tons. It seems probable that the manufacture of bromine and its compounds could be established profitably as adjuncts to the great sea-salt industry on the coasts of India.

Again, quinine is probably the most essential pharmaceutical to any nation, and scarcely any is produced within the Empire; 97 per cent of the world's production of quinine is obtained from Java cinchona bark. If Great Britain desired to render herself independent of Holland in the question of quinine supply she most certainly could do so with ease. In fact, it is difficult to name any essential raw material which could not be produced in either home or colonial territory; owing in the main to neglect of the importance of chemical geography we have allowed ourselves to become so dependent on other nations for necessary materials that our resources become strained immediately our foreign trade experiences disturbance. The many vital problems involved in this large question may well present a fitting subject for treatment by the Ministry of Reconstruction.

From what has been said it will be realised that raw chemical products, great in number, and many of which represent in themselves but small financial interests, are necessary to the maintenance of such enormous industries as those of iron and steel and of textiles. The failure in supply of a little tungsten or a small amount of coal-tar colour almost paralyses industries which are colossal as compared with the tiny industries which can so impede production. Many of the smaller chemical industries are, in fact, key industries, and one of the chief functions of all Government administration of commerce would appear to be to ensure that essential though small chemical industries should be maintained in a flourishing condition and in such circumstances that their breakdown is impossible during any period of crisis.

For illustrative purposes it has been convenient to quote above several industrial chemical operations as instances which show the intimate relationship between chemistry and national prosperity. It is, however, necessary to enquire a little further and to ascertain upon what foundations a flourishing chemical industry is based. All German technological chemical prosperity has been founded upon the conviction that accurate and detailed scientific research is the only sure starting-point for any branch of technical production. It has been realised, not only that some brilliant piece of experimental work is necessary for the initiation of any new technical development, but that incessant scientific work perhaps of rather a routine and uninteresting character, is at least necessary to the development of the new industry; so soon as the scientific study of a technical process stops further development ceases, and sooner or later the process itself becomes obsolete owing to the introduction of some rival method based on more advanced scientific investigation. The neglect of this truth, that technical progress can only result from scientific progress, has been the undoing of a number of British industries.

As an example of this may be quoted the production of indigo. Indigo has been obtained as a vegetable product from time immemorial, and it is no exaggeration to state that the processes still used in India for the separation of indigo from the plant in a marketable form have undergone little change during the past thousand years. With the advance of organic chemistry the artificial manufacture of indigo from coal-tar products became possible, and, as a result of the expenditure of some millions of pounds on chemical investigation, the German colour works succeeded in placing artificial indigo on the market at prices against which the natural article could not compete. During the last few years Mr. Davis and Dr. Armstrong have occupied themselves with the improvement of the natural indigo production, and it seems probable that they are about to establish a conclusion which has suggested itself as a possibility to many chemists, namely, that by attention to plant development, appropriate manuring and improved methods of separation, natural indigo of dyeing properties superior to those of the synthetic article should be produced at a cost which would kill the latter.

The whole question of the problem involved in indigo production is one of peculiar interest. Natural vegetable products are formed as the result of the carrying out of certain chemical operations by the plant; these operations are entirely analogous to those carried on in a chemical works devoted to the manufacture of chemical products, with the distinction that they do not call for the erection of costly plant and works and the running expenditure of large sums on the production of power. Cheap production of a vegetable product by some synthetic works process is thus handicapped in comparison with the natural production in which the plant is its own chemical works, endowed with a remarkably efficient control, drawing its materials from the soil and its power from the sun. There seems no reason why the British Empire, which in some corner or other possesses just the climate and soil necessary to the production of some important low-priced vegetable chemical substance, should allow any of the cheaper chemical materials of vegetable origin to be manufactured at a lower cost in a chemical works.

For many years past it has been said that the artificial production of indiarubber, first effected in England by Tilden, is on the point of successful exploitation as a manufacturing operation in Germany; although considerable quantities of artificial indiarubber have been made in

Germany the cost has undoubtedly been prohibitive to large scale manufacture. A plant which produces a complex organic compound at a cost of anything near a shilling a pound may be safely trusted, if properly handled, to defy all competition on the part of the technical chemist.

In this connection it is interesting to notice that the imminent shortage of foodstuffs in Central Europe has led to organised scientific attempts to utilise vital processes more effectually than hitherto for the production of foods for higher animals. Vast quantities of valuable chemical materials are now allowed to run to waste from many chemical operations because they are dissolved in effluent water in such a state of dilution that their recovery would be unprofitable. Materials contained in dilute solutions are in just the condition which adapts them to recovery or utilisation by some biochemical method; the whole bacteriological purification of sewage is based upon this fact. During the last few years a process has been perfected in Germany for inoculating the waste liquors from sugar refineries, distilleries, paper works, and starch works, with a specific variety of yeast which grows quickly and produces no alcohol; the yeast increases rapidly in quantity at the expense of the carbohydrates in the waste water, and ammonium salts which are added, and is ultimately separated and dried. It is stated that 100 parts of sugar or its equivalent present in the effluent and 37·5 parts of nutritive ammonium salts yield 150 parts of compressed yeast: after drying this contains 40 to 60 per cent of albuminous matter.

The dried yeast, so rich in nitrogenous food materials, is used as cattle fodder, and it is stated that it can be used in human food to replace a large proportion of the necessary albuminoids. The number of works being used for the production of this new foodstuff is being constantly increased.

It will be recognised that the working out of such a salvage process as the one just described has called for the performance of a vast amount of experimental work; the search for just the proper variety of organism by the biochemist and the definition of just the proper conditions for its propagation in the diverse kinds of effluent to which it is to be applied constitutes a really formidable task. It cannot be doubted that the principle underlying the operation is a sound one; other things being equal, it is cheaper to work with the aid of a lower organism than with the assistance of skilled labour and costly plant and equipment. We may expect to see many developments of biochemical industrial processes in the near future.

It has been indicated that pure scientific research forms the basis of all technical chemical progress. The proper appreciation of the national aspects of chemistry must bring with it a great increase in the mass of experimental scientific work carried out in Great Britain; the large output of chemical research in Germany for many years past has borne a direct relation to the development of the chemical industries in that country.

Great Britain has a record in chemical discovery of which she may well be proud, and in consequence many chemical industries may be justly claimed as based directly upon British discoveries. The coal-tar colour industry was initiated by the discoveries of Perkin, and was indeed established by him in this country before it was ultimately transferred almost wholly to Germany. Another instance perhaps less generally known may be quoted.

About a century and a half ago Cavendish discovered that atmospheric nitrogen and oxygen can be caused to combine at the high temperature of the electric spark; this was an observation of purely scientific interest, and has since been used in numberless pieces of scientific work. It was applied by Lord Rayleigh a few years since to the separation of the new element argon from the air.

The shortage of nitric acid, which is so essential to the manufacture of explosives in Central Europe, has led to the systematic study of the large scale combination of nitrogen and oxygen with a view to the use of the reaction in the manufacture of nitric acid. The process of converting the constituents of the atmosphere into nitric acid is completely successful, and is actually in use for the manufacture of most of the huge quantities of nitric acid used in the preparation of explosives for Central Europe. Sooner or later this or some analogous process must be installed in Great Britain for the purpose of replacing Chili saltpetre as a source of nitric acid.

In this, as in the working out of so many other British conceptions, Germany has been at a great advantage over us in that she has been always able to command the assistance of large numbers of competent workers to do the careful and systematic, although unexciting, work necessary to the determination of all the essential conditions governing a particular chemical reaction. For this reason the development of great scientific discoveries made in this country has been too often left to German hands, and the practical fruits of those discoveries have been gathered outside Great Britain.

It is not enough only to lay down and carry out a definite policy concerning the handling of all the raw products of the Empire; it is essential that the policy should be adopted of systematically directing the youthful intelligence of the nation towards natural science, and that the policy should be carried out strenuously and liberally.

THE PREPARATION AND PROPERTIES OF ANILINE STANNICHLORIDE.

By J. G. F. DRUCE.

SEVERAL workers have described various double halides of tin and aniline, which have invariably been obtained from mixed solutions of the component salts, although it has been known for a long time that aniline stannichloride is obtained as an intermediate product in the reduction of nitrobenzene with tin or stannous chloride and hydrochloric acid in the ordinary laboratory preparation of aniline.

Slagle (*Am. Chem. Journ.*, 1898, xx., 633) describes the salt with three molecules of water of crystallisation, $(C_6H_5NH_2)_2.H_2SnCl_6.3H_2O$, which he obtained from mixed solutions in hydrochloric acid containing two molecular proportions of base to one of stannic chloride. His preparation has been successfully repeated, but the compound $4C_6H_5NH_2.SnCl_4.4HCl$, termed tetraniline chlorostannate, and described by Richardson and Adams (*Am. Chem. Journ.*, 1899, xxii., 446), has not been isolated.

The hydrated amine stannichloride was obtained as very pale pink tablets which lost water on heating, and the amorphous residue eventually melted at 292° to a brownish liquid.

On analysis:—

0·4623 grm. gave 0·1210 grm. SnO_2; Sn = 20·62 per cent.

0·2775 grm. gave 0·2409 grm. AgCl; Cl = 37·03 per cent.

$(C_6H_5NH_2)_2.H_2SnCl_6.3H_2O$ requires Sn = 20·74 and Cl = 37·06 per cent.

The salt just described was formed less readily than the anhydrous compound which has been prepared very satisfactorily from nitrobenzene. Ten grms. of the nitro body and 15 grms. of tin were put in a round flask fitted with an air condenser. Concentrated hydrochloric acid was added 10 cc. at a time until 80 cc. had been introduced. The mixture was warmed until the nitrobenzene had disappeared and the metal had dissolved. If the contents of the flask were cooled at this stage the liquid set to a mass of granular crystals (anhydrous stannichloride), but, as the following equation for the reduction indicates, two-thirds of the tin is left as uncombined stannic chloride:—

$$2C_6H_5NO_2+3Sn+14HCl = (C_6H_5NH_2)_2H_2SnCl_6+2SnCl_4+4H_2O.$$

Instead of crystallising at this stage the solution was treated with 200 cc. of warm dilute hydrochloric acid, and 18 grms. of aniline were stirred in to unite with the uncombined stannic chloride. On cooling, an almost quantitative yield of anhydrous aniline stannichloride was obtained.

On analysis:—

0·4289 grm. gave 0·1249 grm. SnO_2; Sn = 22·93 per cent.

0·2675 grm. gave 0·4432 grm. AgCl; Cl = 40·99 per cent.

$(C_6H_5NH_2)_2H_2SnCl_6$ requires Sn = 22·89 and Cl = 40·94 per cent.

If stannous chloride be used instead of the metal the reduction is completed in a shorter time, but there is more uncombined stannic chloride in solution. The equation representing this reaction is:—

$$2C_6H_5NO_2+6SnCl_2+14HCl = (C_6H_5NH_2)_2H_2SnCl_6+5SnCl_4+4H_2O.$$

When aniline was shaken up with twice its weight of hydrated crystalline stannic chloride, $SnCl_4.5H_2O$, in a small stoppered bottle for ten minutes a white pap was produced, resembling that described by Borsbach (*Ber.*, 1890, xxiii., 431) which he obtained with quinoline and stannic chloride. This pap dissolved in warm dilute hydrochloric acid and the solution deposited crystals of the stannichloride.

Aniline stannichloride can also be prepared by reducing azobenzene with stannous chloride and hydrochloric acid. When the reaction was carried out by dissolving 2·26 grms. stannous chloride in 50 cc. of dilute hydrochloric acid (1 : 3) and adding 0·9 grm. azobenzene, the reduction proceeded very slowly unless the mixture was kept hot so that the azobenzene, which is insoluble in water, remained liquid during the operation. The reduction was more rapid when an alcoholic solution of azobenzene, stannous chloride, and hydrogen chloride was employed.

The reduction may be represented by the equation:—

$$C_6H_5N:NC_6H_5+2SnCl_2+6HCl = (C_6H_5NH_2)_2H_2SnCl_6+SnCl_4.$$

As this equation indicates, half of the tin present remains in solution as uncombined stannic chloride, and in the above experiments was present in the filtrates after the aniline salt had been separated. When 0·9 grm. aniline was added to the filtrate and the mixture warmed, a second crop of the double salt was obtained on cooling.

Similarly hydrazobenzene was converted into aniline stannichloride by treatment with stannous chloride and hydrochloric acid. This method of preparing the compound, like the preceding one, is of theoretical interest only. The reaction can be expressed by the equation:—

$$C_6H_5.NH.NH.C_6H_5+SnCl_2+4HCl = (C_6H_5NH_2)_2H_2SnCl_6.$$

Anhydrous aniline stannichloride was colourless when pure and melted at 293° with slight decomposition. It was soluble in water at 16° to the extent of about 28 grms. in 100 cc. The aqueous solution did not hydrolyse unless it was boiled for some time, when hydrochloric acid fumes escaped, or unless it was kept for some days. The presence of a few drops of dilute hydrochloric or nitric acids prevented or greatly retarded this separation of hydrated tin oxide.

On keeping, and particularly in sunlight, the hydrochloric acid solutions slowly darkened in colour and ultimately became quite black and opaque. The presence of a small quantity of nitrobenzene considerably accelerated the darkening. It was found possible to remove this dark colour by warming with stannous chloride solution or with zinc dust, and thus it seems probable that darkening is due to oxidation. No definite substance has been isolated or identified, but the dark body was extracted with ether, in which it was soluble, and apparently a small amount can produce an intense coloration.

Aniline stannichloride was soluble in alcohol but insoluble in ether, chloroform, carbon tetrachloride, benzene, ligroin, and glacial acetic acid.

It dissolved in concentrated sulphuric acid with effervescence, hydrochloric acid gas being rapidly evolved on gently warming. No definite compound was extracted from the residue. When a few drops of a potassium bichromate solution were stirred into the concentrated sulphuric acid solution of the salt an intense blue colour developed.

On adding an aqueous solution of the salt to bleaching powder solution an intense violet colour was produced. The substance also gave the carbylamine reaction for primary amines.

Aqueous and dilute acid solutions of the compound gave a bright yellow colour when dropped on to ordinary paper or wood; pure filter-paper remained uncoloured, which indicates that the stannichloride reacts in some way with lignocellulose.

The substance reacted violently with concentrated nitric acid, and from the reaction product a little *p*-nitraniline was isolated. When boiled with moderately dilute nitric acid nitrophenol was formed.

The aqueous solution of aniline stannichloride reacted strongly acid to indicators, and it has been found possible to estimate the total chlorine in the compound by titration with decinormal caustic soda solution, using phenolphthalein as indicator.

This points to the quantitative character of the action of caustic alkalis of aniline stannichloride. At first the solution became cloudy on addition of alkali, owing to the separation of aniline and colloidal stannic hydroxide, which redissolved when excess of alkali was added. In the volumetric experiments it was found that the pink colour of the phenolphthalein appeared whilst the solution was still cloudy, and the amount of alkali required to colour the indicator was exactly that required to neutralise the hydrochloric acid produced, assuming all the chlorine present was converted into acid by hydrolysis, accelerated by the alkali. Hence the following equation represents the complete reaction:—

$$(C_6H_5NH_2)_2H_2SnCl_6+6NaOH = 2C_6H_5NH_2+6NaCl+2H_2O+Sn(OH)_4.$$

The titration was carried out by dissolving about 0·2 grm. of the salt in about 25 cc. of water, and after adding one or two drops of a phenolphthalein solution the decinormal solution of alkali was run in until the pink colour of the indicator appeared.

The following table indicates the validity of the assumption expressed in the above equation and also the degree of accuracy attained in this method of determining the percentage of chlorine present.

Expt.	Weight of salt taken. Grm.	N/10 NaOH required. Cc.	≡ per cent Cl.	Theoretical per cent Cl.
1.	0·1442	16·70	41·02	40·88
2.	0·1835	21·20	40·96	—
3.	0·2190	25·10	40·64	—
4.	0·2869	32·95	40·70	—

When the compound was heated with an equal quantity of aniline at 150—160° for one and a-half hours a small quantity of diphenylamine was produced. Conditions of temperature and time of heating were varied, but the yield of secondary amine was always very low.

It was thought that aniline stannichloride could be used in Skraup's synthesis of quinoline instead of the aniline and nitrobenzene usually employed, the oxidising functions of the nitrobenzene being undertaken by the stannichloride radical. This expectation has been realised, and a good yield of quinoline was obtained by this method, which does not involve so many operations as the original synthesis, as the following experiment shows.

Fifty grms. of aniline stannichloride were mixed with 50 grms. of glycerol and placed in a round flask of 1 litre

apacity and fitted with a reflux condenser. Fifty grms. of concentrated sulphuric acid were slowly added with shaking; hydrochloric acid fumes were evolved, but there was no great development of heat. On warming with a naked flame the mixture, which was not homogeneous to start with, became quite clear, and on continued gentle heating for an hour a pale brown colour gradually developed. After cooling, the solution was diluted with 400 cc. of water and a solution of sodium nitrite was added to the well cooled mixture until on testing a few drops with starch-potassium iodide indicator the latter turned blue. After standing for an hour the contents of the flask were boiled for twenty minutes and then cooled. The solution was made alkaline with caustic soda and subjected to steam distillation. A milky distillate collected in the receiver, and from this, by extraction with ether, drying over calcium chloride, and distilling off the solvent, 20 grms. of quinoline (b.p. 234—236°) were obtained. This yield is 80 per cent of the theoretical. In the ordinary method of preparing quinoline, using nitrobenzene as the oxidising agent, the yield is said to be 75 per cent of the theoretical (calculated on the weight of aniline taken).

o-Toluidine stannichloride, $(CH_3.C_6H_4.NH_2)HSnCl$, prepared from *o*-nitrotoluene in a similar way to the aniline salt, also gave a good yield of 8 methylquinoline when heated with glycerol and sulphuric acid as in the above modification of Skraup's synthesis.

CHROMITE.*

By J. C. WILLIAMS, Assistant Director, Experimental Ore Dressing and Metallurgical Plant.

Effect of the War.—The production of chrome ore in the United States must be increased. Chrome ore and products derived from it are indispensable in many industries concerned with the manufacture of materials necessary for war purposes. The requirements are far in excess of the domestic production so that the demand for chrome is steadily increasing. Therefore, unless a necessary amount can be produced in this country, requirements must be met by importations from distant sources, for which shipping can hardly be spared. Consequently every effort must be made so that ships now engaged in the transportation of chrome ore may be used elsewhere.

Foreign Deposits.—The most important foreign deposits are those of New Caledonia, Turkey, and Rhodesia. In addition, chromite is mined in small quantities in Russia, India, Australia, Greece, Canada, and Newfoundland. All foreign deposits occur as irregular masses or pockets, similar to the deposits in California, so that mining and treatment methods similar to those used abroad can be used here.

Chrome Ore in the United States.—When it is realised that in 1916 the imports of chrome ore amounted to 114,655 long tons the importance of domestic sources becomes apparent. In 1913 the output in the United States was 244 tons, in 1916 about 47,000 tons, and the 1917 output is estimated to have been 41,000 tons. The yearly requirements are more than 150,000 tons. The most valuable deposits of chrome ore in the United States occur in California, Oregon, Maryland, Pennsylvania, North Carolina, and Alaska. The greatest part of the country's supply is on the Pacific Coast and the greatest demand on the Atlantic. Transcontinental transportation from the producers to the consumers is therefore a large problem in itself. It must be borne in mind, when noting the increase of domestic production from 1913 to 1917, that the ore which has been extracted came from localities which have been well known for a number of years and which were easily accessible. The future production must come, to a large extent, from places difficult of access with probably a long haul to a railroad. Possibly some output may come from small or low grade deposits, in spite of the fact that the final cost of the product will be greater than that of material from deposits of a more favourable nature.

In the United States chromite in commercial quantities was first discovered by Isaac Tyson, jun., near Baltimore, Maryland, in 1827. The story of the discovery and development forms a most interesting chapter in the history of American mining. Tyson had become interested in the recently discovered element chromium, and at that time was probably the only man in America who possessed the knowledge necessary to make use of his discovery. He one day noticed a farmer driving a wagon in which were barrels kept from rolling by blocks of a heavy black ore. These he determined to be chromite. He found the locality from which they came and acquired chromite bearing ground. He studied these deposits and came to the conclusion that chromite would be found only with serpentine, a line of reasoning that enabled him to discover chromite in other localities. From 1828 to 1850 the district near Baltimore supplied most of the chrome ore consumed by the world. The manufacture of chrome yellow was started there in 1828. The export trade from Baltimore came to an end about 1860 on account of the development of the larger and richer Turkish deposits.

Uses of Chromium.—The demand for chrome ore arises chiefly from its use in making alloys, such as ferro-chrome and the like, used in manufacturing steel for projectiles, for armour plate, and for cutting tools, in making refractory chrome brick and furnace lining, in chemical industries for the production of many colours and dyes, and in tanning. Its application for these purposes is increasing, and the demand for it is steadily growing. On account of its great heat resisting qualities chromite is used as a neutral refractory lining for furnaces. It is either made up into bricks with various binders, or lumps of the ore are packed in tight to make a solid lining. Chromite has two valuable qualities for these purposes; it stands change of temperature well and also resists strongly the action of molten metals. For refractories an ore containing 38 to 45 per cent of chromic oxide can be used. The most important use, however, is for making ferro-chrome.

Metallic Chromium.—The word chromium is derived from the Greek word meaning colour, on account of the wide range in colour of various salts of chromium. Chromium also forms the colouring matter of several minerals; the green colour of the emerald is due to chromium. Metallic chromium is not known to occur in the native state. According to Roscoe and Schorlemmer metallic chrome forms a light green glistening powder which exhibits, under the microscope, aggregations of crystals of a tin white colour, with a specific gravity of 6·81. The fused metal is usually as hard and tough as corundum, melts at a higher temperature than platinum, is not magnetic, and, when ignited in the air, is only slowly oxidised. Heated in the oxydrogen flame it burns brightly with emission of sparks, and when fused with saltpetre or potassium chlorate it is converted into potassium chromate. Pure chromium was obtained in 1894 by Moissan by reducing the oxide with carbon in the electric furnace. It is most easily prepared in small quantities by the alumino-thermic process, which consists of reducing the oxide with aluminium powder. Metallic chromium made by this process is used to the extent of several hundred tons a year in the manufacture of high-speed tool steel, as some manufacturers prefer to add their chromium this way rather than as ferro-chrome.

Alloys of Chromium.—The principal alloy of chromium is ferro-chrome; the alloy of chromium and iron, which contains usually 60 to 70 per cent chromium. It is now produced in the electric furnace from high-grade ores. Other alloys of more than scientific interest are chromium with nickel, cobalt, molybdenum, tungsten, manganese, copper, or vanadium, as well as different combinations of two or three of these elements. One of these alloys is called "stellite," and is composed of

* Circular of Information, Colorado School of Mines, Golden, Colo.

cobalt, chromium, tungsten, and molybdenum. It was developed by Elwood Haynes, of Kokomo, Indiana. Two desirable qualities of this alloy are its resistance to corrosion and its ability to take and hold an edge equal to that of the best steel. It may be used for table knife blades, pocket cutlery, surgical instruments, dental instruments, small evaporating dishes, spoons, forks, or scissors.

Chromium in Steel.—Chromium is added to steel in the form of ferro-chrome or as metallic chromium. This steel is particularly adapted for making armour-piercing projectiles, on account of its hardness and also its very high elastic limit. It is also used for armour plate for the same reasons, for parts of crushing machinery, and for very hard steel plate. It is extremely hard, tough, and dense, and possesses great tensile strength. It is especially adapted to severe service and where resistance to abrasion is desired. For the wearing parts of stamp mills, such as battery shoes and dies, cams and tappets, chrome steel has proved to be the most durable and economical material obtainable. Chrome steel in some respects resembles the higher grades of tool steel, but in addition possesses properties combined in no other known steel. It can be made so hard as to be drill proof against the finest tools. These qualities are taken advantage of in the manufacture of burglar-proof safes and jail bars, built up of alternate layers of iron and chrome steel, which cannot be cut or broken. Armour plate contains about 2 per cent chromium and a certain quantity of nickel. Some steels have been made which contain as much as 20 per cent chromium which have unusual qualities.

Ores of Chromium.—Although a number of minerals contain chromium virtually only one—chrome iron ore or chromite—is a commercial source of chromium. However, it is of interest to note that the discovery of the element chromium was made by investigation of the mineral crocoite (lead chromate). The discovery was made by Vanquelin, a French chemist, in 1797.

Description of Chromite.—Chromite (Dana's Mineralogy) isometric. Massive, fine granular to compact. Fracture uneven. Brittle. Hardness, 5·5. Specific gravity, 4·32—4·57. Lustre, sub-metallic to metallic. Colour, iron-black to brownish black, sometimes yellowish red in thin sections. Streak brown. Translucent to opaque. Sometimes feebly magnetic. Composition, $FeCr_2O_4$ or $FeO.Cr_2O_3$ = chromium oxide, 68 per cent; iron protoxide, 32 per cent. Infusible before the blowpipe in oxidising flame; in the reducing flame it is slightly rounded on edges and becomes magnetic. With borax and salt of phosphorus it gives beads which, while hot, show only a reaction for iron, but on cooling become chrome green; the green colour is heightened by fusion on charcoal with metallic tin. It is not acted on readily by acids, but is decomposed by fusion with potassium or sodium bisulphate.

Occurrence of Chromite.—Chromite is a common constituent of basic intrusive rocks, such as peridotites and pyroxenites, and especially of serpentine derived from them. All of the commercial bodies of chromite occur in these rocks. In place it is always found in association with serpentine, which has resulted from the alteration of basic rocks consisting of olivine, hornblende, and pyroxene. In these the percentage of chromium may vary from 0·05 to 0·5. Chrome is by no means an important element in the earth's crust. The average given by F. W. Clarke is 0·033 per cent. Although it occurs usually in basic igneous rocks it is sometimes found in titaniferous iron ores to the extent of several per cent. It is rarely associated with other metallic minerals, except possibly magnetite and nickel minerals. The common form of occurrence is as rounded grains or more often massive granular masses, which resemble magnetite and have sometimes been confused with it, but differ from it in being at the most feebly magnetic. It is a most resistant mineral to weathering. For this reason it is often found in unconsolidated materials such as clay, or in stream materials derived from rocks by erosion. In the weathering of serpentine the more resistant chromite will be concentrated on or near the surface and be misleading as to the richness of the deposit below. Placer deposits of chromite are found where the minerals most resistant to weathering have been concentrated in stream channels, and where these drain areas of serpentine or basic igneous rocks. Along the Pacific Coast there are placers in stream beds and beach deposits which carry, besides chromite, resistant minerals such as gold, platinum, and garnet. The pockety nature of chromite deposits makes the mining very uncertain. There may be one or more of these pockets or lenses scattered through the deposit, but they do not occur with any regularity.

Concentration of Chromite.—The production of a high grade chrome concentrate may be made in two ways:—(1) By hand cobbing, (2) by mechanical concentration. Hand sorting is generally practised in mining the ore, by means of which a high grade product may be made without the losses attendant upon crushing and milling. In milling chromite the general practice is to crush in Blake crushers and then by stamps. The crushed ore is treated by classifiers and fed to tables of the Wilfley type. For deposits such as beach sands, which contain, besides chromite, many minerals with different degrees of magnetic permeability, magnetic treatment is a practical solution of the concentration problem. In general it may be said that a concentrate containing 45 per cent of chromic oxide is sought, as material of this grade finds a ready market at satisfactory prices. In Canada ore containing as little as 10 per cent chromic oxide has been successfully treated.

Recognition of Chromite.—Characteristic features of chromite by which it may be recognised are:—Lustre—vitreous, splendent to metallic or sub-metallic. Streak—dark brown. Infusible before the blowpipe but may fuse slightly in the reducing flame and then becomes magnetic. Usually associated with serpentine. Each grain shows a very smooth conchoidal fracture with high lustre. Bead tests as described under "Ores of Chromium."

Buyers of Chromite.—Consumers of chromite are manufacturers of chrome alloys and refractories. Upon application names of purchasers will be furnished.

Price of Chromite.—The following is a schedule of prices paid by one company purchasing chromite. This is dated May 15, 1918:—We are now paying 1.25 dols. a unit Cr_2O_3 (chromic oxide) for ores containing chromic oxide, 35 per cent minimum; iron protoxide, 15 per cent maximum; phosphorus, 0·10 per cent maximum; sulphur, 0·50 per cent maximum. No attention is paid to the amount of silica or alumina in the ore, although formerly we would not take material containing more than 10 per cent silica." Weights are based on the ton of 2000 pounds. A unit is 1 per cent of this, or 20 pounds. Naturally prices and specifications differ greatly according to the purpose for which the purchaser wishes to use the ore. There are really no hard and fast requirements and no general price can be quoted as the market is liable to change at any time. However, for the past six months the price has been, in general, more than a dollar a unit. In the *Engineering and Mining Journal* of June 8, 1918, is a schedule of prices for chromite ores. The price varies from 0.85 dol. a unit for 30 per cent material to 1.50 dols. a unit for 48 per cent material.

Marketing Chromite.—It should be remembered, in marketing chromite, that it is generally sold f.o.b. cars point of shipment, unless otherwise stated. When a ton is spoken of usually a ton of 2000 pounds is meant. Some companies will not buy ore containing more than a certain amount of impurities such as sulphur and phosphorus; others will, but pay a lower price for them according to the total amount of these impurities.

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To those who desire it the school will, on request, send samples of chromite. Prospectors and others who wish to determine whether they have chromite may send samples to the school which will be tested free of charge. Samples should contain name and address of the sender, and be addressed—Director, Experimental Ore Dressing and Metallurgical Plant, Colorado School of Mines, Golden, Colorado.

THE MANUFACTURE OF LIQUID AMMONIA.*

By W. GREAVES.

PRIOR to the war the very large majority of firms manufacturing ammonia converted it into sulphate of ammonia, and those who did not, and who converted it into what was then called concentrated ammonia liquor, were satisfied if they obtained a liquor containing on an average some 16 to 18 per cent of NH_3. The firms making anything of a higher strength could be counted on the fingers of one hand, and they kept their methods of manufacture very much to themselves. So when a sudden call was made for a solution of ammonia which had to contain not less than 25 per cent NH_3 and not more than 0·5 per cent H_2S at that strength, owing to our lack of knowledge in the manufacture of such a substance, some rather elaborate and expensive plants were recommended, which were anything but efficient, and many of them had to undergo a good deal of alteration before anything like the ammonia returns which were got in the manufacture of sulphate of ammonia were obtained.

In reality, the apparatus for the manufacture of 25 per cent ammonia liquor is exceedingly simple. All that is required is an ammonia still and its accompanying lime still, of such a size that the former is able to deal with the various ammonia waters sent to it without being overloaded, and the latter to be large enough to allow the partially desulphurised liquor to remain in it long enough for the lime to combine with more than sufficient of the sulphuretted hydrogen to bring it below 0·5 per cent in the 25 per cent ammonia liquor, and also with as much of the carbon dioxide and cyanides as possible. The only other apparatus necessary is some form of still to expel as much of the sulphuretted hydrogen as the quantity of ammonia which must be sent to the ammonia still will allow, together with a means of condensing the excess of steam contained in the ammonia vapours in such quantity that, on finally cooling, the resulting liquid wil contain not less than 25 per cent NH_3.

It will thus be seen that the really necessary apparatus for the manufacture of high strength concentrated ammonia liquor consists of few units of simple design. But there are pitfalls in both the design and working of such a plant, which, if not foreseen, will lead to endless trouble and waste of ammonia, and both can be best pointed out by describing an installation for which I acted as consulting engineer. The works at which the plant was to be installed were making sulphate of ammonia, and in order to save both time and expense I desired to use as much of the existing apparatus as possible. There were three ammonia stills already installed, and it was decided to make use of these as follows:—Two of the adjoining stills were used as desulphurisers (one being a spare), and the other was employed as a means of getting rid of some of the water contained in the ammonia vapour, and can be called an ammonia concentrator. There happened to be also on the site a cooling coil and tank, as well as a large storage tank. This necessitated the providing of an ammonia still, lime still, and two reflux coolers, together with the pumps and connecting piping. The method of working is as follows:—

The incoming gas liquor first passes through one of the reflux condensers, where it helps to cool the ammonia vapours from the still, and at the same time is itself warmed up to about 71° C. It then passes on to one of the old ammonia stills, where it meets a little live steam on its way down the still. In this vessel the gas liquor is subjected to partial distillation; the aim being to drive off the largest amount of sulphuretted hydrogen and carbon dioxide with the least amount of ammonia. In this case the gas liquor enters the still at a temperature of about 71° C., and contains 0·75 per cent NH_3 and 0·23 per cent H_2S. The partly desulphurised ammonia liquor leaving the bottom of this still on its way to the ammonia still contains 0·69 per cent NH_3 and 0·15 per cent H_2S. Thus 92 per cent of the ammonia and 65 per cent of the H_2S are being passed on to the ammonia still to be distilled and concentrated.

It may be thought that 65 per cent of the sulphuretted hydrogen is a large quantity to pass on to the ammonia still. It can, of course, be reduced, but it will be at the expense of returning much more of the ammonia along with the waste gases either to a special scrubber, or, if the concentrating plant is connected to a by-product plant, it will put extra work on the ammonia scrubbers. So long as the lime still and the ammonia still are able to extract the sulphuretted hydrogen the more of the latter is passed on the better, as this results in less ammonia being returned with the waste gases. As the quantity of ammonia passing from the desulphuriser to the ammonia still is limited by the amount of sulphuretted hydrogen which can be extraced in the lime still—and I think I am correct in saying that the figure is generally less than the 0·69 per cent I have mentioned—it follows that it is a mistake to work with strong gas liquor when making concentrated ammonia liquor. This was where many people made trouble. At the plant referred to they had added a little more water to the scrubbers till they got their ammonia down. It took about four hours to do it. Now they worked at 0·7 they could turn out a very good liquor.

The waste gases escapieg from the top of the desulphuriser consist of sulphuretted hydrogen, hydrocyanic and carbonic acids, together with the ammonia compounds of these acids. If the tube which conveys these gases is of any great-length, and is cool, it will be found that the ammonium carbonate gradually encrusts on the inside of the tube and *finally blocks it up. This can be easily* overcome by installing a small steam jet, which will allow the carbonate of ammonia to pass away in solution.

The partly desulphurised liquor from the desulphuriser now passes on to the lime still, where the excess of lime combines with the acids already mentioned. I have found it to be an advantage to allow the entry from the lime still into the ammonia still to be made higher than is usually the case when sulphate of ammonia is being

* "Improvements in Apparatus for the Manufacture of Concentrated Ammonia Liquor." A paper read before the Midland Section of the Coke Oven Managers' Association. From *Chemical Engineering and the Works Chemist*, viii., No. 8.

manufactured, as this gives more time for the lime to act upon the ammonium carbonate. It is also necessary to use more lime than is required when sulphate of ammonia is being made, to counteract the hydrolysis of the calcium sulphide.

The ammonia and steam from the ammonia still are conveyed to a reflux cooler in order to extract some of the water-vapours. The cooling medium for this cooler can be the incoming gas liquor, which will absorb some of the heat, and thus will be in a condition to begin parting with some of its impurities as soon as it arrives in the desulphuriser. After this partial cooling the vapours pass to the final reflux cooler, in which they are cooled, so that when they pass on to the final condenser the resulting liquid will contain at least 25 per cent of ammonia.

With an ammonia concentrating plant as above described the following average results are being regularly obtained:—

	Per cent.	Per cent.
Gas liquor	0·75 NH_3	0·23 H_2S
Desulphurised liquor ..	0·69 NH_3	0·23 H_2S
Concentrated liquor ..	28 NH_3 to 30 NH_3	0·20 H_2S
Waste water from still ..	0·006 NH_3	

The temperature at the control points of the apparatus are:—

Gas liquor going to the first reflux condenser	50° F. or 15° C.
Gas liquor entering desulphuriser ..	160° F. or 71° C.
Vapours leaving top of desulphuriser ..	170° F. or 77° C.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Preliminary Report of Inter-Allied Conference on International Scientific Organisations.

Held at the Royal Society on October 9—11, 1918.

Representation.

The following countries were represented:—

Belgium.—Maj. Lecointe, Prof. Massart, M. de la Vallée Poussin.
Brazil.—M. C. M. D., de Carvalho.
France.—M. B. Baillaud, M. G. Bigourdan, M. A. Haller, M. Lacroix, M. Ch. Lallemand, M. Moureu, M. Emile Picard.
Italy.—Prof. V. Volterra.
Japan.—Prof. J. Sakurai, Prof. A. Tanakadate.
Portugal.—Prof. Braamcamp Freire.
Serbia.—Prof. B. Popovitch.
United States.—Dr. H. A. Bumstead, Col. J. J. Carty, Dr. W. J. Durand, Dr. S. Flexner, Prof. G. Hale, Dr. A. A. Noyes.
United Kingdom.—Sir J. J. Thomson (Pres. R.S.), Sir Alfred Kempe, Prof. A. Schuster, Mr. W. B. Hardy, Prof. W. A. Herdman, Sir F. Dyson, Mr. J. H. Jeans, Lieut.-Col. H. G. Lyons, Prof. J. A. McClelland (Royal Irish Academy), Sir E. Sharpey Schafer (Royal Society of Edinburgh), Prof. C. S. Sherrington, Sir W. Tilden.

The delegate nominated by the Government of Portugal did not arrive in England in time to take part in the Conference.

Declaration.

The following declaration serving as introduction to the resolutions was adopted unanimously:—

When more than four years ago the outbreak of war divided Europe into hostile camps, men of science were still able to hope that the conclusion of peace would join at once the broken threads, and that the present enemies might then once more be able to meet in friendly conference, uniting their efforts to advance the interests of science; for ever since the revival of learning in the Middle Ages the prosecution of knowledge has formed a bond strong enough to resist the strain of national antagonism. And this bond was strengthened during the latter part of last century, when branches of science developed requiring for their study the co-operation of all the civilised nations of the world. International Associations and Conferences rapidly multiplied, and the friendly intercourse between the learned representatives of different countries grew more intimate, in spite of their political differences, which were admitted, but not insisted upon.

In former times war frequently interrupted the co-operation of individuals without destroying the mutual esteem based on the recognition of intellectual achievements; peace then soon effaced the scars of a strife that was ended. If to-day the representatives of the Scientific Academies of the Allied Nations are forced to declare that they will not be able to resume personal relations in scientific matters with their enemies until the Central Powers can be re-admitted into the concert of civilised nations, they do so with a full sense of responsibility, and they feel bound to record the reasons which have led them to this decision.

Civilisation has imposed restrictions on the conduct of nations which are intended to serve the interests of humanity, and to maintain a high standard of honour, such as the recognition of the sanctity of treaties—especially those designed to apply to a state of war—and the avoidance of unnecessary cruelties inflicted on civilians. In both these respects the Central Powers have broken the ordinances of civilisation, disregarding all conventions, and unbridling the worst passions which the ferocity of war engenders. War is necessarily full of cruelties; individual acts of barbarity cannot be avoided and have to be borne. It is not of these we speak, but of the organised horrors encouraged and initiated from above with the sole object of terrorising unoffending communities. The wanton destruction of property, the murders and outrages on land and sea, the sinking of hospital ships, the insults and tortures inflicted on prisoners of war, have left a stain on the history of the guilty nations which cannot be removed by mere compensation of the material damage inflicted. In order to restore the confidence without which no scientific intercourse can be fruitful, the Central Powers must renounce the political methods which have led to the atrocities that have shocked the civilised world.

Resolutions.

The following resolutions were passed:—

1. That it is desirable that the nations at war with the Central Powers withdraw from the existing Conventions relating to International Scientific Associations in accordance with the statutes or regulations of such conventions respectively, as soon as circumstances permit; and—

That new associations deemed to be useful to the progress of science and its applications be established without delay by the nations at war with the Central Powers with the eventual co-operation of neutral nations.

2. That certain associations, such as the Metric Convention, depending on diplomatic agreements, be taken into consideration during the peace negotiations.

3. It is not intended that these measures be applied to agreements relating to indispensable administrative relations between public services, such as those regulating navigation, meteorological telegrams, railways, telegraphs, &c.

4. A Committee of Enquiry be constituted by the Conference, the Academies of the countries at war with the Central Powers having power to add further members. This Committee shall prepare a general scheme of international organisations to meet the requirements of the various branches of scientific and industrial research including those relating to national defence. (The Com-

mittee, with Prof. Schuster as Acting-President, will meet in Paris during the second fortnight in November).

5. Each of the Academies represented at the Conference shall be invited to initiate the formation of a National Council for the promotion of the researches specified in Resolution 4.

6. An International Council, having as nucleus the Committee specified in Resolution 4, shall be formed by the federation of the National Councils.

7. The Conference being of opinion that all industrial, agricultural, and medical progress depends on pure science, draws attention of the various Governments to the importance of theoretical and disinterested researches, which after the restoration of peace should be supported by large endowments. The Conference urges similarly the creation of large laboratories for experimental science, both private and national.

Resolved further:—

8. That the resolutions of the Conference 1 to 7 be communicated by the Academies to their respective Governments.

9. That the Academies be requested to inform other learned Societies in their respective countries of the resolutions adopted by the Conference.

10. That the Royal Society be requested to inform—so far as possible—the Bureaux of the International Associations of the resolutions adopted by the Conference with the request that they should take action in conformity with them.

Proposals.

The following proposals were submitted by M. J. Massart, Professor of Botany at the University of Brussels:—

1. To extend the system of international exchanges:—

(a) To effect a gratuitous interchange of publications, having no commercial object (books, separate copies of papers, periodicals, &c.) between authors, societies, universities, museums, libraries, &c.

(b) To allow all scientific establishments in the Allied countries to borrow books from all public libraries, and to provide for gratuitous postal transmission.

2. To unify the courses of study at the universities so as to render possible:—

(a) The exchange of students who might then pursue their studies partly in one and partly in another country.

(b) The exchange of Professors; one might also contemplate the exchange of scientific men who do not belong to the teaching profession, such as astronomical observers, librarians, curators of museums, &c.

3. To organise the publication of bibliographical works in all branches of science so as to render the Allied countries independent of such works as "Central Blatt," "Jahresbericht." The Government should support such enterprises by subscribing to them.

During the discussion of these proposals certain suggestions were made by Prof. Volterra and Mr. Hardy.

Resolution.

Resolved—That the proposals formulated by Prof. Massart, with the suggestions of Messrs. Volterra and Hardy, be referred to the Committee contemplated under Resolution 4, recommending them to their careful consideration.

Resolution.

M. Bigourdan submitted the following resolution:—

That it is desirable to establish a uniform bibliographical notation relating to the whole extent of our knowledge in Pure and Applied Science, Philosophy, Literature, &c.

Resolved—That M. Bigourdan's proposals be referred to the Committee constituted under Resolution 4, recommending them to their careful consideration.

Royal Society Resolutions.

The resolution of the Special General Meeting of the Royal Society held on September 26, namely, "That it is desirable for the Allied nations to establish organisations for scientific co-operation," was adopted by the Conference. It is covered by Resolution 1, and is therefore not repeated separately.

The resolution of the Royal Society with reference to the expulsion of enemy foreign members was submitted to the Conference in accordance with the resolution of the Special General Meeting held on July 31. The subject was discussed by the Conference, but as the sense of the meeting seemed to be that the declaration introducing the resolutions passed by the Conference defined sufficiently the attitude of the Allied Academies towards the men of science of the Central Powers, no further action was taken.

CORRESPONDENCE.

ELEMENTS IN THE ORDER OF THEIR ATOMIC WEIGHTS.

To the Editor of the Chemical News.

Sir,—Referring to Mr. Szymanowitz's letter in the Chemical News (1918, cxvii., 339), if he will consult the following literature he will see that the scheme given is not altogether new, at least not in principle, as the type of regularity shown has been often noticed and expressed mathematically in various ways:—

Comstock on the Rydberg scheme, *Journ. Am. Chem. Soc.*, 1908, xxx., 683.

Sir J. J. Thomson, *Harper's Monthly Magazine*, 1914, 574; "Atomic Theory" (Clarendon Press, Oxford), 1914, 14.

The work of Moseley (*Phil. Mag.*, Dec. 1913, 1024, and April, 1914, 703) confirms the view now generally held that practically all the elements are discovered. The gaps and irregularities, which all the tables of the kind in question (see citations above) show, must be accounted for by some extended scheme, such as one involving *isotopes* (see Soddy, "Chemistry of the Radio Elements," Part II., 1914, Longmans, Green, and Co., and Chemical News, 1913, cviii., 168), if they are to be regarded as of significance (see also Chemical News, 1914, cix., 143). From this point of view the matter is of interest in my opinion.—I am, &c.,

F. H. L.

DEFINITION OF VALENCY.

To the Editor of the Chemical News.

Sir,—There is one point which may be misleading in my article in the Chemical News (1918, cxvii., 319). Referring to Quotation 5 on p. 321, the citation was intended to show an effort in a direction which up to the present has not met with success owing to there being too many exceptions to the rule (2) proposed.

On the same page, Quot. 3, nitric *acid* should read nitric *oxide*.—I am, &c.,

F. H. L.

Biochemical Society.—The next meeting will be the Joint Meeting with the Physiological Society, and will be held on Saturday, November 9, at 3 p.m., in the Physiological Department of the Medical College, London Hospital, London, E. The subject—"Validity of the Isodynamic Law of Nutrition, or Interavailability of Fat and Carbohydrate"—has been arranged for discussion. The discussion will be opened by Prof. Cathcart and Prof. Hopkins.

MISCELLANEOUS.

Synthetic Rubber.—The best test for this, that it cuts like leather, can be confirmed by dissolving in coal-tar naphtha; the appearance in solution differs from that of the natural product.—J. C. THOMLINSON, B.Sc.

Spectroscopy and Dissociation.—In the ordinary wind furnace, using oxygen and coal-gas with a temperature 1800—2000°, the application of a consideration of the spectra involved causes the observation that, whereas potassium and alumina give their spectra at this temperature, there is very little evidence of dissociation of silica as evidenced from the flame at the orifice. The silicon spectrum which can be obtained at the opening between the lid and body of the furnace is not one of dissociation, and evidence that the affinity of potassium and aluminium for oxygen and the corresponding dissociation is very different from the nature of combination in silica which apparently, not showing great affinity of its elements, is very difficult to dissociate.—J. C. THOMLINSON, B.Sc.

Leather Preparation.—Some weeks ago there was some discussion as to the energy relations of sugar solutions. As the subject of solution has concurred with some experiments on the lasting properties of leather, I would point out that nearly fifty years that may be taken as some standard of duration, is a limit to the tanning of leather used for bookbinding at that time. As permanence is a desideratum, briefly alluding to these experiments that refer to sugar solution as confirming a mechanical theory of solution in which the heat of solution follows an atomic equivalence with fair approximation to scientific accuracy, I would mention that a leather preservative which at the same time can be an effective finishing to leather may be found in the fatty acids of linseed oil, and that in tanning processes we are dealing with complicated processes of solution, in which in our present state of knowledge the heat relations of the said processes tend to be too complicated for effective technical control in procuring the desired result.—J. C. THOMLINSON, B.Sc.

New British and Key Industries Exhibition.—His Excellency M. Michalacopoulos, Head of the Greek Commercial Mission at present touring the United Kingdom, paid a visit on October 24 to the New British and Key Industries Exhibition organised by the Industrial Section of the Tariff Reform League. They were met on arrival by Sir Robert Hadfield and Mr. Edward J. Duveen, and were shown round the Exhibition by Mr. Duveen and Mr. Ben Dent. The members of the Mission evinced great interest in what they saw, and expressed their high appreciation of the development of new industries in this country.

Separation of Holmium.—In the August number of the *Journal of the American Chemical Society* Messrs. L. F. Yntema and B. S. Hopkins describe new methods of separating holmium, which is difficult to purify owing to its close resemblance to dysprosium on the one hand and yttrium on the other. By means of four series of fractional hydrolysis of the phthalates the holmium content of a holmium-yttrium mixture was increased from 12 to 25·4 per cent. One series of fractional precipitation with sodium nitrite increased the holmium content 250 per cent in material poor in holmium. The second method is the better because the chemicals employed are cheaper, it is easier of operation, and because an oxide of higher holmium content was obtained by one series of fractional precipitation with sodium nitrite than was obtained from material of the same atomic weight by one series of fractional hydrolysis of the phthalates.

Potash Production in Great Britain.—It is well known that before the war the greater part of the imports of potash into Great Britain came from Germany, refined salts also having been imported from France, Belgium, and the Netherlands, carbonate from Russia, iodide from Japan, saltpetre from India, &c. The potash mines at Stassfurt are said to be capable of supplying the whole world. Great Britain needs potash chiefly for manurial purposes, it being an essential fertiliser for flax, potatoes, and leguminous crops; also for the manufacture of optical glass, for medicinal purposes, and for the newly established dye industry. In a paper read recently at Bristol Mr. Kenneth M. Chance, a Director of the British Cyanides Co., Ltd., described a new and hopeful source of potash which he believed should prove sufficient to supply the needs of the country, namely, blast-furnace gases and dust. It has been found that the percentage of potash can be increased either by raising the temperature of the furnace or by adding a small quantity of common salt to the charge, and by the latter means the quantity of potash volatilised as chloride can be increased nearly sevenfold. A factory for dealing with blast-furnace dust has already been set up at Oldbury, near Birmingham, and others in the neighbourhood of blast-furnaces are in contemplation, and the supplies of potash in the country are steadily increasing, the time of greatest shortage being certainly past.

British Industries Fair, 1919.—For next year's British Industries Fair the Board of Trade have again been able to secure from the Port of London Authority the great warehouses in Pennington Street which proved so highly satisfactory for the Fair held at the beginning of this year. The Fair will be open as usual on the last Monday in February (February 24), and will remain open until Friday, March 7. In order in no way to interfere with the production of munitions the Fair will again be restricted to the same trades which have participated in the last three Fairs, namely:—Glass and Pottery; Paper, Printing, and Stationery; Fancy Goods; Toys. As in past years the invitations to visitors to the Fair will be issued by the Board of Trade, and admittance will be restricted to bona fide buyers interested in the above trades. Over 2000 forms of application for space have already been issued to manufacturers in the trades concerned, and it is expected that the number of firms anxious to participate will be considerably in advance of last year, when orders to the value of over a million and a half were placed. Eligible manufacturers who have not received application forms should, if they wish to participate, communicate at once with the Director, British Industries Fair, Board of Trade, 10, Basinghall Street, London, E.C. 2.

The Investigation of Pulverised Coal Systems in America.—Mr. Leonard C. Harvey, of Red House, Malden, Surrey, has returned from the United States after having carried out for the Director of Fuel Research a full investigation into the progress made in recent years in the application of pulverised coal for metallurgical and general industrial purposes, for steam raising in land and marine boilers and in locomotives on railways. The purpose of the Director of Fuel Research in accepting Mr. Harvey's offer to make this investigation was that the most recent information on the subject of pulverised fuel should be available to all who are interested in the more scientific use of fuel. In order that effect may be given to this intention the information and data collected by Mr. Harvey, together with descriptions of numerous installations inspected and statements as to the actual experience of the owners of these installations, are now been collated in the form of a report. This report will be issued as a Government publication by the Department of Scientific and Industrial Research at an early date. Important developments have taken place in America in the utilisation in pulverised form of low-grade coals of high ash contents, and it is hoped that similar developments will follow the adoption of the system in this country. It is possible that in this way considerable quantities of material which is at present regarded as waste at the coal mines may ultimately be made available as fuel, and thus supplement the restricted supplies of coal.

NOTES AND QUERIES.

, Our Notes and Queries column was opened for the purpose of giving and obtaining information likely to be of use to our readers generally. We cannot undertake to let this column be the means of transmitting merely private information, or such trade notices as should legitimately come in the advertisement columns.

Dutch Metal.—Will any reader kindly inform me as to the chemical constitution of this material.—D. P.

TO comply with Regulation 8 (b) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Assistant Chemist required by large Engineering Works. Knowledge of Gas, Fuel, and Water Analysis essential. Apply, stating age, training, and salary required, to your nearest Employment Exchange, quoting No A 6117. No one at present engaged on Government work need apply.

Chemist, B.Sc., London (Hons. in Chemistry, seeks Research appointment with large manufacturing firm.—Address, G. L., CHEMICAL NEWS Office 16, Newcastle Street, Farringdon Street, London. E.C. 4.

Chemist required at Factory near London. Works experience necessary. £280 with increase to £320 after three months.—Address, stating qualifications, to Box 729, Willings, 125, Strand, London, W.C. 2.

CHEMICAL ASSISTANT.—Well qualified Junior wanted in the Laboratory of a Manufacturing business in Limehouse. State salary and give references.—Address, "Limehouse," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

INDIA.—Chemical Engineer wanted with B.Sc. or equivalent degree; unmarried, ineligible, or discharged. —Address, D. W., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Lady Assistant Chemist required (for Analytical and Research Work) by a Controlled Firm in the Midlands. Must have had a sound training in Theoretical and Practical Inorganic Chemistry. Good salary offered to suitable applicant. State, age, qualifications, and experience.—Address, L. S., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Research Chemist wanted. Knowledge of Organic Chemistry and experience in General Metallurgical Analysis essential. No one at present engaged on Government work need apply.—Apply, stating age, experience, and salary required, to your nearest Employment Exchange, quoting No. A 6131.

Research Chemists wanted, with good knowledge of Physical and Electro chemistry. Salary, £200 to £350 according to qualifications and experience.—Apply to the Salt Union, Ltd., Weston Point, Runcorn.

Wanted, Assistant Chemist with experience in the analysis of Iron, Steel, and Non-ferrous Alloys, for large Works in the North of England. No one at present engaged on Government work need apply.—Write, stating age, experience, and wages required to nearest Employment Exchange, quoting No. A 6182.

Works Analytical Chemist required. One conversant with Soap Manufacture, Nicotine Extractions, and Agricultural and Horticultural Preparations. State full particulars and salary required.—Address, W. A., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, good Analytical Balance, also Refractometer, Polarimeter, Viscometer, and Flash Point apparatus.—Address, "Apparatus," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, CALORIMETER for Fuels—Mahler Bomb, Rosenhain, or other standard pattern. State full particulars and price.—Address, "Calorimeter," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, GAS ANALYSIS APPARATUS in good working condition with sampling outfit.—State price and full particulars to Redbourn Hill Iron and Coal Co., Ltd., Frodingham, Scunthorpe, Lincs.

Wanted, BECKMAN THERMOMETER. Please send particulars to "Thermometer," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, POLARIMETER. Anyone wishing to dispose of one please send particulars of the instrument to "Polarimeter," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

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Head of the Department—Prof. F. S. KIPPING, Ph D., D.Sc., F.I.C., F.R.S.

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Applications should be accompanied by copies of three recent Testimonials (original Testimonials must NOT be sent).

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FRAS. C. FORTH, Principal.
Municipal Technical Institute, Belfast.

COMPETITIVE ESSAYS on "EXPLOSIVES."

The DORSET FIELD CLUB announce that the CECIL MEDAL and PRIZE of £10 will be awarded in May, 1919, for the best paper on "Explosives used in Warfare from the time of the Crusades to the present War, giving details (unobjectionable from a military point of view) of each invention, and the chemical proportions of the substances used in each case, commencing with gunpowder and Greek fire." Open to any person between the ages of 17 and 35 on May 1, 1919, either born in Dorset or resident not less than one year between May 1, 1917, and May 1, 1919.

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For further details apply to the SECRETARY.

ORDER THE PAPER.

In consequence of the "No Returns Order" of the Government, readers of the "Chemical News" are requested to ensure a regular supply of the paper by placing an order with their Newsagent.

THE CHEMICAL NEWS

VOL. CXVII., No. 3061.

SPECIAL NOTICE TO SUBSCRIBERS.

THE recent paper restrictions have compelled us to publish only fortnightly instead of weekly for a time, but we are now glad to be able to announce that we are to be allowed a further supply of paper, which will enable us to revert to weekly publication in the near future.

Beginning with No. 3064, to be published on January 3, 1919, the CHEMICAL NEWS will again appear weekly, and the dates of expiration of subscriptions will be adjusted accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their subscription periods. The price will remain unaltered, viz., £1 for fifty-two numbers, or *pro rata*.

ON NUCLEIC ACID AND ITS ANALYTICAL EXAMINATION.

By A. CHASTON CHAPMAN, F.I.C.

DURING recent years nucleic acid and certain of the metallic nucleates have found somewhat wide and increasing application in medicine, and particularly in connection with surgical practice. At the outbreak of war these substances were obtained chiefly from Germany and America, and so far as I am aware were not manufactured at all in this country. A number of urgent inquiries having been received from France and elsewhere, the Pharmaco-Chemical Products Company, Ltd., suggested to me that I should undertake the investigation of this matter with the object of devising methods for the manufacture of pure nucleic acid and its derivatives on a large scale. Yeast was obviously the most convenient raw material, and for more than a year the above-mentioned company have been manufacturing considerable quantities of pure yeast-nucleic acid and its compounds.

It will be obvious that, in the prosecution of this work, it was necessary to have methods for examining the products obtained and to establish analytical *criteria* of purity. The production of pure nucleic acid on a large scale presents many difficulties, the two chief ones being the complete removal of protein and the prevention of the contamination of the acid with the products of its own decomposition. This will be at once apparent when it is remembered that nucleic acid results from the breaking down of the nucleo-proteins of the cell nuclei on the one hand, and that, on the other, it yields, as the result of further hydrolytic change, a number of complex nucleosides and bases, together with phosphoric acid and the carbohydrate *d*-ribose. The conditions for hydrolysis have therefore to be very exactly determined and very strictly observed in practice.

Up to the present two nucleic acids have been very fully studied, the one derived from yeast, the other from the thymus gland. Whether these two acids represent typical members of two sharply defined groups, or whether all nucleic acids are identical with one or the other, is at present a little doubtful. The latter view is, however, the one more generally held, and the nucleic acid from yeast is frequently known by the more comprehensive term "plant-nucleic acid." It is with this plant nucleic acid that the present paper chiefly deals.

The following statement shows at a glance the chief products of hydrolysis of these two nucleic acids, and at the same time affords an insight into their respective chemical constitutions:—

Plant Origin.—Guanine, adenine, cytosine, uracil, *d*-ribose (pentose), phosphoric acid.

Animal Origin.—Guanine, adenine, cytosine, thymine, lævulinic acid (from a hexose), phosphoric acid.

Plant nucleic acid is a white friable substance devoid of odour or taste, and having the formula $C_{38}H_{50}O_{29}N_{15}P_4$. It is practically insoluble in water, but dissolves readily in solutions of alkaline acetates. It is also readily soluble in solutions of the alkalis forming the soluble alkaline salts. From these solutions a few drops of hydrochloric acid precipitate the nucleic acid in a dense curdy form, which dissolves completely on the addition of a large excess of the acid.

When acetic acid is added to a solution of the sodium salt the acid is partly precipitated, but no precipitate is formed on the addition of any acid in the presence of a sufficient quantity of alkaline acetate.

When added to a solution of sodium nucleate a solution of copper acetate acidified with acetic acid gives a bulky greenish blue precipitate.

Calcium chloride in excess in the presence of a few drops of acetic acid gives a white precipitate at first flocculent, quickly becoming more granular.

Silver nitrate, when added in considerable excess to a fairly strong and neutral solution of sodium nucleate, gives a white gelatinous precipitate. On the addition of a little sodium chloride this dissolves, forming an opaque colloidal solution. One drop of hydrochloric acid added to this precipitates the silver as chloride.

Solutions of sodium nucleate in water exhibit a marked tendency to gelatinise, and, if sufficiently strong, set to a jelly.

The above reactions, coupled with the recognition of guanine and adenine (which are the most easily isolated and best defined of the bases formed on hydrolysis), suffice for the identification of nucleic acid, when it exists in a fairly pure condition.

For the hydrolysis of nucleic acid 10 grms. of the acid (or a larger quantity if available) are heated in a boiling water-bath for two hours with 40 cc. of 10 per cent sulphuric acid (or a proportionately larger quantity if more than 10 grms. are taken) in a small flask fitted with an air condenser. At the end of this time strong ammonia is added to the hot solution in the flask until the liquid contains an excess of about 2 per cent. The guanine is precipitated in a granular form, the adenine remaining in solution. After filtering and washing with 1 per cent ammonia the guanine is dissolved in the smallest possible quantity of dilute sulphuric acid, decolorised if necessary by means of a little animal charcoal, and the base precipitated again from the colourless solution by the addition of an excess of ammonia. The purified base may then be converted into the hydrochloride, which crystallises very readily and may be easily identified by the application of any of the well known tests. The ammoniacal filtrate from the guanine, together with the ammoniacal washings, is acidified with sulphuric acid, heated to boiling, and the adenine precipitated as a cuprous compound by the addition of a 10 per cent solution of copper sulphate. Inasmuch as the solution contains the carbohydrate ribose it is not necessary to add sodium bisulphite for the purpose of reducing the cupric compound. The adenine-copper compound is suspended in hot water, decomposed with sulphuretted hydrogen, and the filtrate from the copper sulphide evaporated to dryness on the water-bath. The residue, consisting of nearly pure adenine, is dissolved in 5 per cent of sulphuric acid, and the adenine sulphate, which is readily soluble in hot, but very slightly soluble

in cold water, allowed to crystallise. The usual tests can then be applied.

The following is an outline of the procedure to be adopted for the examination of nucleic acid, with the object of ascertaining its purity and quality.

The acid should be white or at the most have a very faint buff colour. It should be completely soluble in an aqueous solution of sodium acetate or in dilute solutions of ammonia or of sodium or potassium hydroxides. The solutions in these reagents should be bright and almost colourless. When a few drops of hydrochloric acid are added to a solution of the sodium salt in water the acid should be precipitated as a white curdy substance, and on the further addition of a large excess of the hydrochloric acid this should dissolve completely. An aqueous solution of the sodium salt should give with cupric acetate, calcium chloride, and silver nitrate the reactions described above.

Tests for the Absence of Protein.

Biuret Reaction.—A solution of the acid in an excess of caustic soda should give, on the addition of one or two drops of dilute copper sulphate solution, a greenish blue colour with at the most a faint tinge of purple. The test is quite sufficient, but occasionally the following test is applied:—

A 5 per cent solution of nucleic acid in a small excess of ammonia, when heated in a bath at 105° C., should give at the most a slight turbidity.

In connection with these tests it may be pointed out that the removal of the last traces of protein matter from nucleic acid involves a very troublesome series of treatments, and that acid of high commercial quality will usually give an indication of the presence of traces of protein when subjected to the above tests. The second of the above tests is the more severe, inasmuch as an amount of protein equal to not more than 0·1 or 0·2 per cent (expressed on the acid) gives a very appreciable volume of precipitate.

Inorganic Phosphate.—To a solution of the acid in excess of ammonium or sodium acetate a few drops of acetic acid are added, and then a little uranium acetate. A flocculent precipitate is formed, which in the absence of more than a trace of inorganic phosphate should dissolve completely on boiling. A considerable excess of alkaline acetate is necessary in this test.

Estimation of Nitrogen and Organic Phosphorus.

Nitrogen.—This is estimated by the Kjeldahl method in the ordinary way.

Phosphorus.—A weighed quantity of the acid is fused with six times its weight of sodium carbonate containing 10 per cent of potassium nitrate. The fused mass is taken up with water, and in this solution the phosphoric acid is estimated either by the molybdate method or by direct precipitation with magnesia mixture in the presence of a little ammonium citrate.

It will be seen that the formula given above corresponds with 16·1 per cent of nitrogen and 9·5 per cent of phosphorus.

Commercial nucleic acid of good quality ought to contain not much less than 15 per cent of nitrogen and 9 per cent of organic phosphorus (expressed on the moisture-free sample). The examination of nucleic acid should always include these two items, and the ratio of the percentage of organic phosphorus to that of nitrogen is one of the best *criteria* of the purity of the acid, since, if this ratio (1 : 1·7) is approximately correct, the presence of any appreciable proportion of the products of hydrolysis is excluded.

DISCUSSION.

The CHAIRMAN (Mr. W. T. Burgess), in inviting discussion, remarked on the high percentage of nitrogen which nucleic acid contained, and asked whether it could be estimated satisfactorily by the Kjeldahl process, or whether some "ultimate" process would have to be used.

Dr. WYNTER BLYTH, referring to the identification of the nucleic acid by the production of adenine and guanine, asked whether there was any other method which would require smaller quantities than 9 or 10 grms., and also whether Mr. Chapman could say how the nucleic acid was secreted, and in what manner it affected the urine. Presumably the phosphates would be increased, and possibly the amino-acids.

Capt. R. H. A. PLIMMER asked whether Mr. Chapman had any further information on the subject of the increase of leucocytosis by nucleic acid used in surgical injections. It had been shown that meat extract caused an increase of uric acid in the urine, and meat extract contained purine and pyrimidine bases, which were constituents of nucleic acid. This suggested that the uric acid might be produced from the pyrimidine bases, but it might be the result of some synthetic process in the body. He had been hoping that Mr. Chapman would have described some method for the quantitative chemical analysis of the decomposition products—for the estimation, for instance, of the quantity of guanine yielded. Such quantitative analysis was a difficult matter, and Mr. Chapman's paper gave an increased power to deal with it. Some years ago Professor Scott and he (the speaker) had discovered a method of detecting the minutest quantities of inorganic phosphorus or phosphate mixed with organic phosphorus compounds, using an ammonium molybdate reagent made with hydrochloric acid and containing some potassium persulphate. A mixture containing organic but no inorganic phosphorus compounds gave merely a yellow coloration, but if inorganic phosphate was present a yellow precipitate was produced.

Mr. H. F. E. HULTON asked whether Mr. Chapman would include absence of the biuret among his criteria of the purity of nucleic acid.

Mr. CHAPMAN, in reply, said that the total nitrogen in the nucleic acid was readily obtained by the Kjeldahl process. As to the question of obtaining enough guanine and adenine for purposes of identification, there was no difficulty nowadays in obtaining sufficient nucleic acid to enable one to work with the 10 grms. required for this purpose. He was sorry to say that he had no information as to the form in which nucleic acid was excreted. A great deal of work had been done on the action of various enzymes on nucleic acid, but precisely what happened to the phosphates or to the other constituents he was not able to say.

Capt. PLIMMER said that the phosphates were increased in the urine, and to a probably greater extent in the fæces.

Mr. CHAPMAN, continuing, said that he did not know precisely what happened in connection with the increased leucocytosis which resulted from the use of nucleic acid, nor did he know the reason for the increase. That it did occur there could be no reasonable doubt, for the German literature on the subject was specially voluminous, and numerous experiments on this property of nucleic acid had also been made in France. Nucleic acid was, in fact, being used in considerable quantities for this particular purpose, and appeared to afford material help. He had not attempted the estimation of guanine, which would be a troublesome process and beyond the scope of his immediate object. The production of guanine and adenine by hydrolysis had been recommended merely for the purpose of effecting some more complete identification of the nucleic acid itself. He was much obliged to Captain Plimmer for the reference to his special molybdate reagent, and should certainly try it. He was obliged also to Mr. Hulton for his reminder about the biuret reaction, which was, however, dealt with in the paper. This reaction should be practically absent. On dissolving the acid in a slight excess of caustic potash or soda and a few drops of copper sulphate there should be not more than the faintest possible tinge of purple; more than that would, of course, indicate the presence of protein.—*The Analyst*, July 1918.

THE ACIDIMETRY OF COLOURED SOLUTIONS: AN APPLICATION OF THE POCKET SPECTROSCOPE.

(PRELIMINARY NOTE).

By ALFRED TINGLE, Ph.D. Customs Laboratory, Ottawa.

IT became necessary at the Customs Laboratory, Ottawa, to make acidimetric titrations of deeply coloured alkaloidal solutions, and it was found that the colouring matter could not be removed without vitiating the quantitative nature of the results. Ordinary methods of meeting the difficulty having failed it has been found that the spectroscope offers a solution.

The absorption spectra of indicators are, of course, markedly different in acid and in alkaline solution, and the presence of an independent spectrum, arising from the natural colouring matter, does not prevent the observation of the first one, unless, indeed, it should happen that in some individual cases the two spectra overlap.

In practice the author has found it very nearly, if not quite, as accurate to determine the end-point of an acidimetric titration spectroscopically as with the naked eye, and the spectroscopic method is certainly available in many cases where otherwise no end-point could be seen. Obviously it can be used at night as easily as in day time.

The Spectroscopic Method.

Two similar vessels are provided, one of which holds the solution to be titrated, the other an equal volume of distilled water. To the latter is added one drop of the standard alkali to be used, and then an accurately-measured quantity of the indicator. The latter is added, a little at a time, till the characteristic absorption band shows a sharp enough edge. The quantity of indicator is noted, and the position of the edge of the band is also noted. This position marks the end point.

The same volume of indicator solution is next added to the liquid to be titrated, after which titration is carried out in the ordinary way but for the fact that the spectroscope is used in place of the naked eye to watch the change of colour. In most cases this will be found to result from the shifting of an absorption band rather than the substitution of one band for another. The shifting may be gradual, but when the band watched has reached the position registered for it in the "blank experiment," the end-point has been reached. In every case, it need hardly be said, the same thickness of liquid must be examined, but the shape of the vessel is of no importance. The author has often used a conical flask and obtained as good results as with any other container.

The spectroscope used in this work was a direct-vision Beck-Thorp diffraction instrument. It is one of the cheapest on the market and extremely convenient. A large spectroscope would be very unsuitable for such a purpose as the present one, but any handy instrument could be used. No attempt has been made to express numerically the positions of the bands of the different indicators worked with. These vary with the dilution, thickness of layer examined, and perhaps other factors, and each worker must find those conditions best suited to his own peculiar eyesight.

In the following experiments the volume of liquid worked with was in each case about 60 or 70 cc., and the thickness of layer examined about 45 mm. The solutions were contained in flat-sided tincture bottles. It will be noted that the volume of indicator used is much larger than would be suitable were observations being made with the naked eye.

Experimental Results.—Every indicator hitherto worked with has been found to have its own peculiarities, which must be carefully studied before it can be used in connection with the spectroscope. Some of these are still being looked into, and at present the author can only give details of methyl-orange and cochineal.

A reliability test was made by measuring out definite quantities of decinormal sulphuric acid, colouring these with carefully neutralised extracts of black tea or stick liquorice, so that the end point would not be visible to the unaided eye, and then titrating by the method outlined above against decinormal soda.

Exp. No.	Vol. of N/10 H_2SO_4 by measurement (cc.)	Vol. of N/10 H_2SO_4 found by titration (cc.).
Indicator used—Cochineal, 2·5 cc.—		
1.	15·0	15·21
2.	26·0	25·98
3.	20·0	19·96
Indicator used—Methyl-orange, 1 cc.		
4.	21·0	21·01
5.	17·5	17·49
6.	14·0	14·11
7.	18·5	19·16

The failure in the last case quoted appears to have been due to a temporary defect in the source of light. This trouble was not suspected till the readings had been taken and the solution thrown away, so that re-titration was impossible. As a further factor in considering the degree of accuracy it should be noted that while performing these titrations the author did not know what result he might expect, the acid having been measured by Mr. Babington, the Chief Analyst to the Customs, the amounts not being disclosed till the titrations were completed. For this and much other help in other directions the author's best thanks are due to Mr. Babington. The cochineal solution used was a saturated extract made with 50 per cent alcohol. The methyl-orange solution was 0·1 per cent of colouring matter in water.

Lately, Mr. Babington and the author ("Chemical Industry in Canada during the War," x., 32) commented on the different titre shown by solutions according to whether cochineal or methyl-orange is used as indicator. The spectroscopic method appears to bring methyl-orange back into line with cochineal and lacmoid. Figures cannot be quoted at present, but it is apparent that the spectra of neutral methyl-orange and alkaline methyl-orange are the same. From this it follows that the usual practice with this indicator of titrating to an intermediate tint is mistaken. *Alkali should be added till the fullest change to yellow has taken place.* Cochineal, on the other hand, changes colour as it becomes more alkaline.

The author hopes shortly to publish a more complete account of this work in connection with other indicators. —*Journal of the Society of Chemical Industry*, xxxvii., No. 8.

Federation of British Industries.—The members of the Federation of British Industries representing the great body of the manufacturers of this country desire to offer to His Majesty the King their respectful homage and congratulations upon the wonderful success which has crowned the efforts of the British Empire and her Allies in the struggle which has been brought to such a glorious conclusion. They also desire to offer to the Forces of the Crown of all three services and from every part of the Empire, profound appreciation and thanks for the superb courage and endurance with which they have borne the terrible trials of the past four years. They tender to the Right Honourable D. Lloyd George, the Prime Minister, an expression of their sincere admiration and thanks for the magnificent courage, steadfastness of purpose, energy, and skill with which he has guided the Nation through years of the gravest difficulty and anxiety to final victory. They also desire to express their sincere and hearty appreciation, which is based upon actual knowledge and experience, of the loyal and devoted service which has been been given by the staffs and workpeople of the manufacturing and business establishments of this country throughout the period of hostilities, which has contributed in such great measure to the success of the Allied cause.

A NEW FORMULA FOR THE CALCULATION OF ADDED WATER IN MILK.*

By LESLIE J. HARRIS.

The calculation of the percentage of added water in milk from the deficiency of solids-not-fat below some fixed standard (*e.g.*, 8·50 per cent) is inaccurate. A new formula is given introducing a compensation for cases where the rising of fat globules has produced a depression of solids-not-fat in the creamy fraction. The formula is—

$$W = 100 - \frac{10{,}000\ N}{N'(100-F)+F'N},$$

W being the required percentage of added water.
N = percentage of solids-not-fat in milk.
F = " " fat in milk.
N' = " " solids-not-fat in standard.
F' = " " fat in standard.

This formula is scientifically accurate if milk be regarded as an emulsion of fat globules in a solution (or pseudo-solution) of solids-not-fat. A previous formula proposed by Richmond—

$$W = 100 - \frac{F+G}{34{\cdot}5} \times 100$$

is arbitrary and of only approximate accuracy.

A mathematical treatment is given of the variation in composition of milk on standing. The solids-not-fat are shown to vary directly as the final non-fatty milk constituents, and inversely as the original non-fatty milk constituents.

* Summary of a Paper in *The Analyst*, October, 1918.

COLLOIDAL SILVER.

By ALWYN PICKLES, B.Sc.

During a silver recovery from residues the following perhaps unusual change took place. The silver chloride was converted to the oxide, Ag_2O, in the usual way, and thoroughly washed.

To show its reducing power formaldehyde 60 per cent was used for the ultimate reduction. This operation was carried out in a vessel containing a mechanical stirrer. At room temperature, 14° C., reduction was slow, and nothing out of the ordinary happened. On raising the temperature to 35° C. reduction was accelerated, but the liquid was found to be acquiring a pale lilac tint increasing in intensity as reduction proceeded. This solution passed unchanged through ordinary filter-papers, and has been preserved since the experiment—June, 1917. The colour of the solution is now a rich ruby-red.

The experiment was repeated using acetaldehyde, but no similar result was obtained. Possibly the acetic acid produced, less volatile than the formic acid produced above, was sufficiently ionised to ensure immediate coagulation of the colloidal particles formed.

Further experiments dispensing with continuous stirring and elevation of temperature gave no result in several cases, and in others only after several days, the colour produced being only slight.

There seemed reason for suspecting colloidal silver. The following experiments gave some support to the idea:—

1. The colour was discharged by salt solutions, though only slowly. Nitric acid was most effective especially on warming.

2. Hydrogen peroxide was slowly decomposed on slightly warming. The peroxide solution was, however, very dilute—4 volume.

ENEMY METHODS OF GAS WARFARE.

In April, 1915, a German deserter in the Ypres salient gave warning of the first attempt to use poison gas in modern warfare. No one believed him; but a week later the enemy launched his first attack with chlorine gas against our unprepared and unprotected troops, and claimed subsequently to have killed 6000 men and to have taken an equal number of prisoners. Since that time gas warfare has become a combination of a science and an art, and its development shows the usual struggle between attack and defence, and in this case between poison and antidote.

The first method used took the form of a gas cloud. The cylinder was covered with a layer of moss containing potassium carbonate solution, and surrounded by sand bags. When the attack was made the protective covers were removed, and the cylinder connected with a lead pipe bent over the top of the trench. The success of such an attack depends largely on physical conditions. The wind direction must lie between two straight lines which make angles of 40° with the neighbouring sections of the front, and its velocity must be within the limits of four and twelve miles an hour. An upward current is the worst foe of gas, and the ground should slope gently away from the point of emission. Above all, the element of surprise plays a very important rôle. The gas used must be easily compressible, easily made on the large scale, of high density and toxicity, and preferably of low chemical activity. Thus the choice is practically limited to two gases, chlorine and phosgene.

Chlorine suffers from the defect of being too chemically active and therefore too easily absorbed. The first protection against it consisted of pads of cotton-wool soaked in solutions of sodium thiosulphate and carbonate. The type changed every week, till finally a helmet was introduced, consisting of a flannel bag soaked in the above reagents and containing a mica window. This proved an efficient protection.

Phosgene was first used in December, 1915, by the Germans, but, thanks to our Intelligence Department, the danger was foreseen and provided against by the issue of helmets containing sodium phenate. These gave adequate protection when the gas concentration did not exceed 1 : 10,000, but as the enemy was soon able to increase the concentration a more efficient absorbent had to be found The Russian suggestion of using hexamethylenetetramine, $(CH_2)_6N_4$, was adopted. In conjunction with sodium phenate it gave protection against gas concentrations of 1 : 1000 for a considerable time. The type of respirator was changed to the box type, which strikes a useful balance between the efficiency of a larger apparatus and the lightness and convenience so essential in a gas mask. Thus an oxygen apparatus would be useless on account of its weight and short life. "The side that can first force the other to use oxygen respirators for protection has probably won the war."

Besides the antidotes already mentioned, activated charcoal, another Russian suggestion, is much used. Charcoal and alkaline permanganate will protect against nearly every gas, even up to concentrations of 10 per cent for short periods.

The German apparatus, which is not so efficient as ours, consists of a small drum attached to the face piece of the respirator and containing three layers of materials, viz., pumice soaked in hexamethylenetetramine, charcoal, and on the outside baked earth soaked in potassium carbonate solution and coated with charcoal.

In all probability the method of attack by gas cloud has had its day, everything pointing to the gas shell as being the more deadly weapon and the more capable of development. The term "gas shell" is somewhat misleading, as the contents are generally liquid or solid, but the materials used are vaporised or atomised by the explosion, a proper adjustment between bursting charge and poison being necessary. The chief advantages of a gas shell are:—It is not dependent on the wind, it can be fired with all the accuracy of modern gunfire, and it does not require a

special corps for its application. On the other hand, a shell does not produce more than about 6 lb. of gas, whereas a German cylinder contains 40 lb.

The first type to be used was the tear shell, the "lachrymator" being pure xylyl or benzyl bromide. The bromination had apparently been carelessly performed, about 20 per cent of the inactive dibromide being present. These shells "neutralised" units temporarily, instead of putting them out of action, but before long the highly poisonous trichloromethyl-chloroformate, $ClCOOCCl_3$, came into use. This has no action on the eyes, and hence is difficult to detect.

The next stage was the introduction of a substance which simultaneously harassed and injured the enemy. The most important of these is the dreaded "mustard gas," dichloro-diethylsulphide, $(CH_2ClCH_2)_2S$, which has no immediate effect upon the eyes beyond a slight irritation, but produces extremely painful after effects; the eyes swell and blister, the nose discharges freely, and coughing and vomiting occur. Direct contact with the skin also produces blistering, and the concentrated vapour penetrates clothing. The Germans scored heavily with the use of this shell until our counter-measures proved effective.

Other surprises of the enemy were phenyl-carbylamine chloride, a "lachrymator," and diphenyl-chloroarsine, a "sneezing gas," which makes the victim sneeze so violently that he is prevented from using his respirator. A modern gas bombardment would consist of a carefully adjusted mixture of these types.

In addition to the substances already mentioned the following have also been used:—

In shells:—Allyl iso-thiocyanate, bromated methyl-ethyl-ketone, dibromo-ketone, nitro-trichloro-methane (chloropicrin), dichloro-methyl-ether, sulphur trioxide.

In hand grenades:—Bromoacetone, bromine, chloro-acetone, chloro-sulphonic acid, dimethyl sulphate, methyl-chloro-sulphonate.

Prussic acid has not been used by the enemy, being rated apparently below phosgene.

"Both sides are busy trying to find something that the others have not used, and both are trying to find a 'colourless, odourless, and invisible' gas that is highly poisonous. It is within the realm of possibilities that the war will be finished, literally, in the chemical laboratory" (S. J. M. Auld, of the British Military Mission, *Journ. Wash. Acad. Sci.*, 1918, viii., 45).—*Journal of the Society of Chemical Industry*, xxxvii., No. 7.

Salters' Institute of Industrial Chemistry.—The Court of Assistants of the Salters' Company have appointed Martin Onslow Forster, Esq., F.R.S., D.Sc. (Lond.), to be the first Director of the Salters' Institute of Industrial Chemistry. Dr. Forster will enter upon his new duties at an early date. The new Director of the Salters' Institute is a distinguished chemist, who, from July, 1915, till the present time, has been Chairman of the Technical Committee of British Dyes Limited, and also until recently a Member of the Board of Directors. He is Honorary Treasurer of the Chemical Society, and a Member of the Council of the Royal Society.

Competitive Essays on Explosives.—The Dorset Field Club is well known as an energetic body which has in the course of its activities of various kinds done much to spread a knowledge of science, and in this connection attention may be called to the Prize and Medal which are *now being offered for an* "Essay on Explosives and their Use in Warfare." Details of this interesting competition are to be found in our advertisement columns. The subject of the essay should offer ample scope to the scientific knowledge and literary ability of young chemists, and we hope that large numbers of our readers will avail themselves of this opportunity of entering for a competition from which even the unsuccessful are bound to derive considerable benefit.

SUGAR FROM SEVERAL POINTS OF VIEW.

By GEORGE MARTINEAU, C.B.

(This paper is written to prove, from the history of sugar during the last sixty years:—1. That nascent industries can be encouraged, research stimulated, and efficiency created, by a rational, well regulated, but moderate stimulus. 2. That preferential treatment in home markets is the best, perhaps the only, way to give real confidence to capital; and that with that confidence, coupled, of course, with favourable natural conditions, British industries will flourish, and may even become capable of furnishing the whole consumption of the Empire. 3. That the dumping of commodities below cost price is a fatal injury to the consumer).

Dr. H. C. Prinsen Geerligs, in his fine work on "The World's Cane Sugar Industry, Past and Present," gives a long and interesting account of the early history of sugar. He goes back to Hindu mythology. A certain famous hermit, once upon a time, was desired by an Indian prince to procure for him permission to be translated to heaven during his lifetime. This was refused, but the hermit kindly furnished for him a temporary paradise on earth. This seems to have included, among its many delights, the sugar cane. After the destruction of this paradise, the sugar cane was spread all over the world as a memorial of the famous hermit. No date is mentioned.

When we emerge from these pre-historic times we again meet with real sugar, for the first time, in India. It is called "gur" in India now, and that seems to have been its name from very early days.

In the seventh century, A.D., the fact is on record that a Chinese Emperor sent people to India to learn the art of sugar manufacture. The natives in India at the present time are content to produce "gur" by boiling down the juice from the cane till it solidifies. But it appears that even in that early period the Arabs, when they got hold of the sugar cane, learned to purify the raw sugar by re-crystallisation and to produce a great variety of sweetmeats.

In the thirteenth century travellers reported the existence of many sugar factories in China. Then we hear of the Arabs taking the sugar cane to Sicily, and thence to Africa. Thus it spread all round the coasts and islands of the Mediterranean. The Crusaders found extensive sugar plantations in many parts. Spain boasted of a flourishing sugar industry even in the twelfth century. From China the sugar cane found its way to the Indian Ocean, to Siam, the Philippines, Formosa, and Japan. But in those days it was only in China and the countries round the Mediterranean that a real sugar industry existed. The Crusaders took a great interest in the cultivation of the sugar cane, and founded many important centres of the industry.

When these early industries produced more than they consumed a trade in sugar sprang up. The Crusaders, when they got home, began to import it, and a brisk trade started between the Italian ports and Northern Europe. It is curious to note that in these early days the traffic was in refined, not raw sugar. This is easily explained by the fact that the art of sugar-refining had not yet reached to Northern Europe. It was actually loaf sugar that the Crusaders and others imported from the Mediterranean ports. We hear of Damascus and Tripoli becoming great sugar-refining centres in the fourteenth century.

Then, alas! in the fifteenth century the Turks began to overrun these countries, and the sugar industry had a bad time; in fact, as Dr. Prinsen Geerligs says, "the once flourishing sugar industry of the Mediterranean was condemned to extinction." But, in the meantime, the Portuguese took the sugar cane to Madeira, the Azores, the Cape de Verde Islands, and the Gulf of Guinea. Spain colonised the Canary Islands. In all these places a new sugar industry sprang up and flourished, especially

with the help of slave labour. Then came America. Spain, Portugal, Holland, Great Britain, and France colonised a vast territory, and sugar, instead of being a fancy luxury, soon became an article of common consumption. Fertile land, a favourable climate, and cheap labour formed the basis of the great sugar industries of the West. First Brazil, then the West India Islands, English, French, Spanish, and Dutch, then other countries on the mainland of America, Surinam, Demerara, Berbice, and finally Peru, Argentina, Chile, Mexico, and Louisiana. The competition from these new countries soon extinguished the little industry in Madeira, the Cape de Verde, and the Canary Isles.

France introduced sugar cane into Mauritius and Réunion, which soon began to export sugar to Europe. Early in the eighteenth century the Dutch East India Company, which had been importing sugar from Formosa, Bengal, and Siam, introduced the sugar cane into their Island of Java; but the wonderful success of that most remarkable of all cane-sugar industries did not take place till long afterwards.

Then, at the birth of the nineteenth century, came the great war between France and Great Britain, and the cane-sugar industry had a bad time. Naval engagements in West Indian waters, the sinking of sugar cargoes, the capture of merchant ships, not only from the West but also from the East, and other blows dealt by France at British trade, did not conduce to the development of the cane-sugar industry. Finally came Napoleon's "continental system."

I am much obliged to Dr. Prinsen Geerligs for enabling me to give this brief sketch of the early history of cane sugar, and can now go forward to my own personal experiences from 1856 to the present day.

In 1856 our industry of sugar-refining was in a flourishing state. Practically all the loaf sugar consumed in this country was produced in the East End of London, where about twenty refineries, each doing a few hundred tons a week, were very busy, giving work and wages to the surrounding neighbourhood, and keeping the London Docks fully occupied with the thousands of hogsheads of West India sugar which were annually imported. That was the sugar which we principally used, helped out with sugar from Mauritius, British India, the foreign West Indies, and the foreign East Indies. The total, in 1856, was 384,000 tons of raw cane sugar, to which must be added 9000 tons of foreign refined sugar and 4000 tons of raw beetroot sugar. This gives a total consumption of 397,000 tons. The remarkable point is that of the 384,000 tons of raw cane sugar 285,000 tons, 70 per cent, came from our own sugar-producing British Possessions, East and West, but especially West. Those were good days, not only for British sugar-refining but also for the British West Indian Colonies and Mauritius. It will be interesting, for a moment, to look at the kind of sugar which the world produced in those days, and especially at our largest contributors, the British West Indies.

The British West Indian sugar of sixty years ago was an excellent class of raw sugar, so good, in fact, that a considerable portion of it was pure enough to go direct nto consumption, and it is with regret that those who were intimately acquainted with it view its impending abolition. It was well made, with great skill and care, a skill which has probably by this time nearly died out. It was a primitive process, but much superior to other primitive processes of those days, some of which, unfortunately, still survive. It was called "muscovado sugar," and was produced by a simple process, giving a good result when well done, but very different to present requirements.

At the date with which we are now dealing the world produced about 1,200,000 tons of cane sugar and 250,000 tons of European beetroot sugar—total 1,450,000 tons. The cane-sugar producing countries of those days, mentioned in the order of their importance, were Cuba, Java, Mauritius, the British West Indies (including British Guiana), Brazil, Porto Rico, Manilla (the name in those days for sugar from the Philippine Islands), Réunion, Louisiana, and the French West Indian Islands of Martinique and Guadaloupe. The finest raw sugar came from Java, Mauritius, the French West Indies, Réunion, and Louisiana. Cuba made a semi refined raw sugar called Havana, but the bulk of its production was a muscovado sugar, very inferior to the British variety. Porto Rico, on the contrary, produced a very fine muscovado sugar, quite fit for direct consumption. The sugars from Brazil, Manilla, and British India were very low brown impure varieties, requiring a great deal of refining. The British refiners were experts with that class of sugar, while the foreign refiners, in France and Holland, preferred the easier work—mere child's play—with a raw material of a much higher grade, in fact, almost pure.

The British sugar refining industry in 1856 was not confined to London, though London produced practically the whole of the loaf sugar which we consumed. Bristol was a very old-established centre of the industry. The great house of Finzel, then the largest refinery in the country, was celebrated for its large grained crystallised sugar, and was the first to use the newly invented centrifugal machine. Liverpool also was a large contributor to our refined sugar production. Ships from Brazil were constantly arriving in the Mersey and bringing, among other things, the low brown sugar from that country. In the Clyde also a new and flourishing industry of sugar-refining was springing up. It increased with great rapidity, having discovered a new way of producing yellow sugar of very superior colour and quality, a kind popular with the buyers of the cheapest article. The history of the rise and progress of this industry is interesting, as an indication of the vicissitudes through which the sugar-refining industry of this country had to pass between 1887 and 1903.

In 1854 the sugar refiners of Greenock (and Glasgow) imported 50,000 tons of raw sugar. In 1865 they imported 136,000 tons, and the figure went on increasing rapidly until, for the five years 1877-81, the average yearly importation was 248,429 tons. This figure held till 1887, when a fall, as rapid as the rise, set in. For the five years 1887-91, the average yearly imports had fallen to 228,733 tons, for the following five years to 170,373 tons, and for the years 1897-1900, to 124,874 tons, a lower figure than that from which they started in 1865. Presently we shall see the reason why.

This is the completion of our brief sketch of sugar sixty years ago. Let us turn to another picture—after a violent revolution. The last year of the nineteenth century, 1900, was a record year in the history of sugar. Our consumption had risen from 397,000 tons to 1,624,000 tons—more than four times as much. That is a wonderful fact, but another, far more incredible, comes next, namely, that out of this enormous quantity of sugar consumed in the United Kingdom only a little scrap, 129,000 tons, was produced from the good old sugar cane. Even that small quantity would not have come to us had it not have been for two facts—first, that our Colony of Demerara produced a very choice kind of yellow crystallised sugar which a few intelligent connoisseurs insisted upon having; and, secondly, because two of our sugar-refining firms stuck to cane sugar, hoping to obtain a fancy price for their refined sugar. We hope they did.

But there is one more almost equally incredible fact to be revealed. The world's production (not including the imaginary figure for British India, which now confuses our statistics) had increased from 1,450,000 tons to 8,291,800 tons—nearly six times as much. Now comes the most wonderful fact of all. Of this quantity, only 2,880,900 tons was the product of the sugar cane—less than 35 per cent; in other words, nearly two-thirds of the world's production of sugar came from the beetroot fields of Northern Europe and, to a small extent, from the beetroot fields of the United States. These facts are worth looking into, in order to discover causes for such

startling effects. I could spend several hours in explanation—all of it interesting—but we must be brief.

There is no need to go into the history of the origin of beetroot sugar here; suffice it to say that Napoleon Bonaparte had something to do with it, and also the King of Prussia. I said that in 1856 Europe produced about 250,000 tons of beetroot sugar. That was doubled in ten years, and in five years more the production exceeded a million tons. Another ten years raised the figure to two millions. This brought cane and beet neck and neck in the race; then beetroot shot ahead to three, four, five, and six million tons.

There are two causes at the bottom of this mystery. Energy, ability, efficiency, and, more than all, persistent research, constituted the first and best cause. But this best cause is not to be had, as a rule, unless you give it a stimulus. Capitalists do not care to risk their money unless they can see very clearly that there is some security for their investment. That is exactly what the European beetroot-sugar industry enjoyed; all except France, who had to languish till 1884. France gave the research most liberally, but she lacked the stimulus.

It was Germany that hit upon the right kind of stimulus. It was a brilliant idea, quite an inspiration, and was carried out with great judgment. The sugar duty was levied—not upon the sugar produced, but upon the roots. This at once stimulated the farmer to produce the richest possible quality of root, and the manufacturer to extract from the root the largest possible quantity of sugar. Great pains were taken to breed an improved variety of sugar beet. This great research lasted for years, and still goes on. Its success was astounding—incredible. At the beginning the sugar-beet contained less than 6 per cent of sugar. In France it continued to contain less than 6 per cent of sugar until the stimulus was applied in 1884 to save the life of the industry. But in Germany the roots went on, year after year, increasing in richness until, in 1908, the average quantity of sugar actually extracted from the roots for the whole of Germany was 17·63 per cent. I used the word "incredible," and it is the only word to use. The natural quantity of sugar contained in the sugar-beet had been multiplied by three. For the ten years 1899-1908, the average yield for the whole of Germany was 15·49 per cent. This shows what can be done by giving a rational and very moderate stimulus. That this wonderful result was caused by the stimulus—plus, of course, great efficiency—is proved by the lamentable fact that poor France, who received no stimulus till 1884, was at that date getting a yield of less than 6 per cent of sugar, while Germany at the same time was producing 11 per cent of sugar from the roots as the average for the whole country. France hastened to adopt the German system, but never succeeded in catching it up in the race. The average yield for the ten years 1899-1908, which, as I have said, was 15·49 per cent for Germany, was only 12·84 per cent for France. This is the worst of being "too late." In industry it is fatal. Austria, with a system similar to that of Germany, got a yield of over 15 per cent for those ten years.

Research was still rampant, and the breeding of the rich roots led to the invention of the diffusion process—another result of the stimulus. This process, now brought to great perfection, practically extracts the whole of the juice, and in a very pure state. In my book on sugar I gave the results of a good German factory in 1908, from which it will be seen that the average quantity of sugar contained in the roots worked by that factory throughout the season was 17·10 per cent, and that the quantity actually extracted was 16·64 per cent. These figures show what can be done when efficiency reigns supreme, and they are also a good illustration of the perfection to which chemical control of a sugar factory can be brought. Everything that happened is known, down to the second place in decimals. France, so long as she worked roots containing less than 6 per cent of sugar, could not attempt the diffusion process.

Another instance of the valuable results of research is the multiple evaporator, called by the French the "Triple Effet." The French had a considerable share in bringing this invention to a practical success. It has enabled the sugar factory to perform the most important and expensive part of its process—that of evaporating the thin juice till it is thick enough to crystallise in the vacuum pan—with the lowest possible expenditure of fuel. Research is still going on with regard to this part of the process, and has not yet said its last word.

Greatest of all the results was the gradual development of the new method of purifying the juice, called the double carbonatation process. We have no time, on such an occasion as this, to describe processes, but I can safely assert that this must be regarded as one of the greatest of all the results of the researches of the last fifty years in the world of beetroot sugar. It has now found its way to Java, where fine white sugar is being produced in large quantities by means of it. But here again there is no finality, and it is quite possible that a still better process, giving equally good results at less expense and trouble, may eventually take its place. Research is still busy with it.

The great cane-sugar industries of the world did not take a *laissez-faire* view of the subject. They immediately buckled to and set their house in order. They at once adopted the multiple evaporator, and now every modern factory has one, or perhaps several. The diffusion process was tried, but found to have too many drawbacks when applied to cane-sugar production; but they were determined to try to extract if possible nearly the whole of the juice in the cane. Instead of having only one three-roller mill, which squeezes the cane twice, they now have four, placed tandem fashion with travelling bands between, and thus give the cane eight squeezes. They also place two rollers with rough surfaces at the entrance to the first mill, which crack the hard crust of the cane before it enters the mill. With these improvements and "maceration" of the "megass" (the crushed cane) in its transit from mill to mill, they now extract 95 per cent of the juice, and are ready to fight the beetroot industry. Instead of hundreds of tons, they are turning out thousands from each factory, and thus reducing cost of production. They have, however, their own special difficulties to surmount. Labour is one of the greatest. Here Java is in a favoured position. She has also good soil and climate, great efficiency in management, and a fairly good system of irrigation. The necessity of supplying the cane with sufficient water is vital, and water is not always attainable.

The cost of production depends, to a great extent, on the quantity of canes per acre which can be produced. Java produces more than forty tons as an average for the whole of the island, and can therefore produce sugar at a very low cost, all the factory arrangements being thoroughly efficient. Half of Java's crop of about 1,500,000 tons (rapidly increasing) is now produced in the form of white granulated sugar of high quality, which goes to British India for the benefit of the upper classes. Our Colony of Mauritius is doing the same, and deserves to succeed after all the cruel troubles she has gone through. White sugar direct from the beetroot juice has been produced for a long time. The present writer recollects seeing one beetroot factory in Germany, as long ago as 1871, turning out good loaf sugar; and at a later date he saw Eugen Langen, the inventor of the cube-sugar process, producing very fine cubes at his factory at Elsdorf direct from the beetroot juice.

This great effort of the cane-sugar industry to compete with beetroot brings us to another striking result of giving industry a stimulus. I have shown how the German stimulus, rationally applied, led to greater efficiency, profound research, and most astounding results. I have compared it with the sadly backward state of the same industry in France, so long as it received no stimulus. And yet I find, if I consult a recent utterance of the

Council of the Manchester Chamber of Commerce, that industries receiving such a stimulus are bound to become "apathetic and inefficient." Very well, I have given facts of practical experience in flat contradiction to this doctrine—a doctrine, by the way, which the members, as distinguished from the Council, of the Manchester Chamber have now, I am glad to see, repudiated most emphatically.

I will now give more facts of practical experience, this time from the cane-sugar industry, which again will prove conclusively that this doctrine, so glibly repeated as if it were an axiom, is an absolute delusion. The United States of America gave preferential treatment in their own markets to sugar produced in their own states, territories, and dependencies. They also gave a slight preference—rather more than half a farthing a pound—to their *protégé*, Cuba. Let us see what has been the result of this preference—absolutely inappreciable to the consumer. Cuba, before the Spanish-American War, just succeeded in producing a million tons of sugar per annum in the years 1894 and 1895. After the American occupation in 1898, and when the unfortunate industry had succeeded in recovering from the devastation of the war, the stimulus of the small preference began to tell. In 1903 Cuba got back to the million ton figure. In 1913 it produced 2,500,000 tons, and last year it would have produced 3,500,000 tons, but, unfortunately, when the sugar was badly wanted, an insurrection broke out in the eastern part of the island, and the actual production was reduced to 3,000,000 tons. This enormous increase was the result of the security capitalists found in the small American preference. Large factories were erected, railways connecting them with the shipping ports were constructed, everything was done in the most up-to-date style, and the only trouble was to get the sugar sold and shipped as soon as possible. The United States markets were glutted during the thickest part of the crop time, and prices went down sometimes more than £2 per ton below the European level. The American consumer actually gained by the preference.

In Cuba at the present time there are many factories that turn out from 10,000 to 20,000 tons of sugar per annum. There are about the same number which turn out from 20,000 to 40,000 tons. There are eight that turn out from 40,000 to 60,000 tons. There are three that turn out from 60,000 to 80,000 tons. There is one that produces between 80,000 and 100,000 tons, and there is one that produces more than 100,000 tons per annum. This is the "apathy and inefficiency" created by giving a preference!

The greatest research now going on in the cane sugar industry is the breeding of new varieties of cane which shall give more sugar, resist disease, and be suitable for various soils and climates.

I will conclude by giving one more instance of the results of preferential treatment in the home market. We know from recent experience how comfortable it would be if we could produce enough sugar for our own consumption without going to foreign countries for it. The United States are now in that happy position. Since the preference was granted Louisiana has increased her production from 95,000 to 414,000 tons; domestic beetroot from 1000 to 779,000 tons; Hawaii (the Sandwich Islands) from 12,000 to 602,000 tons; Porto Rico from 50,000 to 400,000 tons; the Philippine Islands from 92,000 to 300,000 tons; and, finally, Cuba from 1,000,000 to 3,500,000 tons. If America had not created this great increase in production by giving a preference to her own family and friends we should at the present moment be suffering—and so would America—from a real sugar famine. Instead of that what do we see when we turn to American statistics for 1915? In that year the consumption of sugar in the United States amounted to the large figure of 4,257,713 tons, every ounce of which, with the purely accidental exception of 23,000 tons, came from her own states, territories, and protectorates. This striking fact is entirely the result of giving a preference. The United States, so far as sugar is concerned, is now independent of the outside world, and is even able to spare us a million tons from Cuba whenever we are short of supplies.

This ends my essay. There is another essay that might be written from the opposite point of view, showing the injury done to our sugar industries by competitors armed with an artificial stimulus. I have dealt with that, and with the economic questions connected with it, in a little book entitled "A Short History of Sugar, 1856-1916, a Warning," to which I desire to refer my present audience. But as I made a passing reference to the injury done to our refining industry, as illustrated by the serious reduction in the industry on the Clyde from 240,000 tons per annum in 1882-86 to 125,000 tons in 1897-1910, it is necessary to point out that the cause of this collapse was the enormous importation of foreign refined beetroot sugar, at prices with which the unstimulated producer could not compete. For many years nearly a million tons were imported every year, the sugar being landed at every little port around our coasts. The Brussels Convention came into force in 1903, and the Clyde industry, which can work as cheaply as any refining industry in the world, revived. In 1913, the last year before the war, the Clyde refiners melted 231,333 tons, nearly as much as at the height of their remarkable prosperity in 1877-1886.

A distinguished—shall I say economist?—has recently proclaimed that "the millions should not be deprived of cheap sugar even if it be dumped." To this most attractive exclamation there are three most conclusive contradictions, founded on facts derived from the history of sugar during the last forty years. Those facts prove—first, that the fleeting pleasure of buying a commodity below cost price is disastrous to the consumer, because it is bound to be followed by reduced production and higher prices. Secondly, that under such circumstances the stimulated industry again takes the lead, increases its production, forces down prices once more, and gets one step further on the road to monopoly. That is exactly what happened to sugar. Thirdly, it is a fact that the millions have never been deprived of cheap sugar, except when there happened to be a bad beetroot crop, which is a periodical occurrence. Then prices go up. The dumped sugar, in which the consumer revelled, has made him more and more dependent on the beetroot crop for his supply; when that fails he has to pay the penalty. Then the war broke out, away went the whole of his dumped supply—and now, he is on rations.

These are the conclusive answers to this profound economist. He should begin by trying to master the rudiments of his subject.—*Journal of the Royal Society of Arts*, lxvi., 474.

The New British and "Key" Industries Exhibition.—The Executive Committee of the Tariff Reform League decided last year to arrange a series of popular illustrated lectures on the so-called "Key" industries, the great national and imperial importance of which has been so clearly demonstrated during the war. It was speedily recognised, however, that an Exhibition would be of considerably more value than lectures, and accordingly the New British and "Key" Industries Exhibition was organised at the Central Hall, S.W. 1. The catalogue of the Exhibition shows that a thoroughly representative collection of exhibits, sent by some of the most important firms in the country, has been brought together, and besides lists of these exhibits the catalogue contains short articles on some of the chief industries—coal-tar dyes, chemical glass, tungsten, and other metals, for example. The Tariff Reform League is also establishing a bureau of Key Industries in which information relating to them is being brought together and made available for educational purposes.

PROCEEDINGS OF SOCIETIES.

INSTITUTE OF CHEMISTRY.

At a meeting of the Council of the Institute of Chemistry held on Friday, October 25, the Registrar reported that he attended meetings for the formation of Local Sections of the Institute held at Liverpool (September 12), Manchester (October 4), Gretna (October 21) Edinburgh (October 22), and Glasgow (October 23).

At each meeting the objects of Local Sections were discussed, and the views of the members were obtained on a new scheme for the election of Council and on the Draft Rules for Sections. The views of the Sections on these matters will be submitted in due course to the General Purposes Committee.

The Council also approved of proposals for the formation of Sections in Birmingham, South Wales, and in Ireland.

The Registrar also reported that he had attended meetings in connection with the Officers' Resettlement Committee, Ministry of Labour, at which he had promised that the Institute would do all it could to find appointments for chemists who had served with the Forces, and suggested that other representative professional bodies would be prepared, similarly, to help their respective members and students.

A letter was received from the Salters' Company forwarding a copy of the particulars of the new Research Institute, and expressing their thanks for the evidence given by the Registrar before their Committee.

On the Report of the Nominations and Examinations Committee the Council elected 23 new Fellows and 88 new Associates, and admitted 14 new Students to the Register.

The Finance Committee reported that they had under consideration the need for raising the amount of the Annual Subscription in view of the increased general establishment expenses and the growing activities of the Institute.

A sum of about £2500 is yet required to complete the Building Fund.

The General Purposes Committee reported that they had considered the position of the Institute in connection with the proposals contained in the Whitley Report. A letter had been addressed to the Minister of Labour pointing out that, although modern productive industry depended so much on the work of chemists, engineers, and the like, such technical experts do not appear to have any place in the constitution of the Industrial Councils; but in view of the fact that it was proposed that the Industrial Councils should deal with such subjects as technical education and training, industrial research, utilisation of inventions and improvements, and industrial experiments, the Minister of Labour had been asked—(*a*) Whether it was intended that qualified professional technical experts should be represented on the Industrial Councils, and (*b*) whether it was desired that the professional bodies representing such men should be brought into consultation in any way in connection with the technical matters referred to.

The Public Appointments Committee reported on the representations made to the Corporation of Birmingham with reference to the action of the Municipal Research Laboratory in sending out pamphlets and letters soliciting practice in competition with private chemical practitioners. The Council hoped that the differences which have arisen between the Research Laboratory and professional chemists in Birmingham might be satisfactorily and amicably adjusted, and have suggested that there should be no serious obstacle to such solution, since, on the one hand, it is admitted that there is room for a Municipal Laboratory, while, on the other, assurance had been given to the City Authorities that they have no desire to prejudice the interests of professional chemists.

The Public Appointments Committee are also watching the interests of professional chemists in connection with the proposed Bill for the establishment of a Ministry of Health, and, having in view the greatly increased working costs of public analysts, they have expressed the opinion that such officers are fully justified in appealing for a reconsideration of their contracts.

On the recommendation of the same Committee the Council have approved a statement on the necessity for a definitely organised Government Chemical Service, which will shortly be brought to the notice of all Government Departments concerned.

Mr. Horatio Ballantyne, Vice-President, reported on the representations made to the Board of Trade by a deputation from engineering and technical institutions with reference to the proposed Patents and Designs Bill, and on the evidence given by him on behalf of the Institute. It is understood that the views expressed by the deputation are under consideration by the Board, and that the presentation of the Bill in Parliament has therefore been temporarily delayed.

SOCIETY OF GLASS TECHNOLOGY.

The first meeting of the 1918-19 Session was held on Wednesday, October 23, in the University, Sheffield. Dr. M. W. Travers, F.R.S., presided over a well attended gathering, and in his opening remarks referred to the great loss the Glass Industry has suffered in the death of Mr. A. S. Esslemont, C.B.E., Controller of Optical Munitions and Glassware Supply. He paid a tribute to the great work of Mr. Esslemont in stimulating the industry, and the Society unanimously resolved to forward an expression of sympathy to the family of Mr. Esslemont together with an appreciation of his great services.

A report of the activities of the Society since the June meeting was given by Dr. Turner, the outstanding feature being the institution of a Refractories Research and Specifications Committee, charged with the drawing up of specifications for the various refractory materials used in the glass industry, and with the promotion of research upon the same subject. The Council of the Society appeals for the co-operation of every member in assisting the Refractories Committee in its arduous labours. To stimulate interest, the Council had decided to devote the first meeting of the Session to a discussion on refractories.

The first paper, entitled "*Refractory Materials and the Glass Industry*," was read by Prof. J. W. Cobb, B.Sc., F.I.C. He emphasised the fact that although temperatures in glass manufacture were by no means abnormally high, yet the nature of the chemical reactions taking place was such as to render the problem of refractories extremely difficult. There was the corrosive action of the molten glass upon the container to contend with, and in addition the corrosive action of hot dust upon flues and furnace interiors. The nature of the various refractory materials used in the glass industry was then dealt with, and the effect of grain size on the refractories and strength of silica bricks received thorough treatment. Special emphasis was laid upon the necessity for the smallest joints in building up of refractory materials, and furnace building should be regarded rather from the standpoint of masonry than of bricklaying. The paper closed with a discussion of the evil effects on refractories of penetration of glass and batch materials, and the importance of thermal conductivity.

Dr. M. W. Travers, D.Sc. F.R.S., then contributed a "*Note on the Firing of Glass Pots.*" By means of a striking collection of specimens the author showed that the life of a glass pot was materially increased if, before filling in, the pot was completely "vitrified." Ways and means of carrying this out were given, and the reason why vitrification before filling gave such good results was fully discussed.

A third paper on "*The Requirements of Clay for Glass Pot Making*" was contributed by Mr. S. N. Jenkinson. A brief survey was made of the position of the Glass Refractories Trade both in 1914 and at the present time, and the necessity for some specification of materials was shown to be urgent. The proposed specification drawn up by the Refractories Committee for clay for pots was then dealt with and its various sections discussed. The question of size, nature, quality, and function of "Grog" received full treatment.

Mr. Coad-Pryor read a short note on the "*Action of certain Types of Glass upon Pots*," and discussed the reason for the quicker solution of the bottom of glass pots as opposed to the sides. Several interesting experiments were described dealing with this problem.

Dr. Turner and Mr. J. H. Davidson contributed a short note on "*The Solubility of Pot Material in Glass*," and showed the influence of grain size upon rate of melting.

A full discussion followed the reading of the papers, in which Prof. Fearnsides, Mr. Hartley, Mr. Connolly, Mr. Teisen, Mr. Rees, Dr. Searle, and the authors of the papers took part.

The November meeting of the Society will be held in Leeds.

NOTICES OF BOOKS

A Text-book of Inorganic Chemistry. Edited by J. Newton Friend, D.Sc., Ph.D., F.I.C. *Vol. V. Carbon and its Allies*. By R. M. Caven, D.Sc. (Lond.), F.I.C. London: Charles Griffin and Co., Ltd. 1917. Pp. xxi+468. Price 15s. net.

The carbon group of elements is one of particular interest, both from the theoretical and practical points of view, and the author of this volume had before him a very difficult task when he set out to prepare a complete account of the chemistry of the elements belonging to it. The difficulties of selection and arrangement and of condensation within moderate limits of the vast amount of material relating to the group which has been collected have been most successfully met, and for advanced students of inorganic chemistry the book will be found a very reliable work of reference in which English and foreign literature is well summarised. After a scholarly and particularly interesting introduction to the group as a whole carbon and its most important compounds are discussed, including some of the hydrocarbons and a few substances such as urea, which for no very good reason are usually relegated to books on organic chemistry. A short account is given of the manufacture of coal-gas, and in every way the author has endeavoured to make his treatment of the subject complete without sacrificing succinctness. Silicon is naturally given less space, but is equally well treated, the natural and artificial silicates in particular being very fully discussed. The detection and estimation of the elements by the most recent and satisfactory methods is in all cases very well described. In the case of tin and lead a condensed account is given of the metallurgy of the elements. The chapter on thorium gives a *résumé* of the radio-activity of thorium, and the properties of the disintegration products are shown in a table. The book can be confidently recommended for the use of students and practical men, and in every way it will be found a satisfactory addition to the series to which it belongs.

Royal Institution.—A General Meeting of the Members of the Royal Institution was held on the 4th inst., His Grace the Duke of Northumberland in the Chair. Special Thanks were returned to Mr. R. Pearce for his Donation of £100 to the Research Fund. It was announced by the Secretary that the Christmas Course of Juvenile Lectures would be delivered by Prof. D'Arcy Thompson, the subject being "The Fish of the Sea."

MISCELLANEOUS.

Royal Institution.—The Ninety-third illustrated Christmas Course of Juvenile Lectures, founded at the Royal Institution in 1826 by Michael Faraday, will be delivered this year by Prof. D'Arcy Thompson, C.B., F.R.S., his title being "The Fish of the Sea." The subjects are as follows:—Jelly fishes, Tuesday, December 31; Star-fishes, Thursday, January 2; Cray-fishes, Saturday, January 4; Cuttle-fishes, Tuesday, January 7; The Herring-fishery, Thursday, January 9; The Whale-fishery, Saturday, January 11. The lecture hour is 3 p.m.

North London Medical and Chirurgical Society.—A clinical meeting of this Society was held at the Great Northern Central Hospital on Thursday, Nov. 14, at 8 p.m. The President, Surgeon General Arthur E. Edmunds, C.B., M.S., F.R.C.S. (a member of the Hospital's Honorary Staff), took the Chair, and Dr. Alexander Morison and Mr. Fred Stocker, F.R.C.S., presented medical and surgical matters for discussion. There was a considerable attendance of North London medical practitioners.

Mineral Resources of Great Britain.—The Board of Agriculture and Fisheries desire to give notice of the publication of the Seventh Volume of the Special Reports on the Mineral Resources of Great Britain (Lignites, Jets, Kimmeridge Oil-shale, Mineral Oil, Cannel Coals, Natural Gas), which have been prepared by the Director of the Geological Survey in response to numerous enquiries that have arisen through the conditions brought about by the War. This volume deals with the Lignites of Bovey Tracey, the explorations which have been made in them by Germans and others, and the uses to which they have been put. Other less important examples of lignite are enumerated, and an account is given of the uses and working of jet, the distribution and qualities of Kimmeridge oil-shale throughout the country are described in detail. The principal known occurrences of mineral oil are also dealt with. The existence of cannel coal, under its various names, is recorded for many coalfields, and an account is given of the presence of natural gas in various formations, apart from coal measures. The volume deals with England and Wales. Copies (price 2s. 6d.) may be obtained through any bookseller, from Messrs. T. Fisher Unwin, Ltd., 1, Adelphi Terrace, London, W.C. 1 (who are the sole wholesale agents to the trade outside the County of London), or from the Director-General, Ordnance Survey Office, Southampton.

Journal of the American Ceramic Society.—The first issue of this monthly journal, devoted to the science and technique of the ceramic industries, has just appeared. The American Ceramic Society belongs to the older family of scientific societies in the United States. The first meeting of the Society, which was in reality a little family gathering of a small group of ceramic enthusiasts, was held in Columbia, Ohio, in February, 1899, and from that meeting grew the present organisation, due largely to the guiding genius of Prof. Edward Orton, jun., of Ohio State University. The membership has increased from that early day until at present there are over 1000 enrolled in the Society. In the American Ceramic Society the term "ceramic" is synonymous with "silicate industries," and the interests and activities of the Society include all branches of the clayware, glass, and cement industries, as well as enamelled wares of all kinds, and in addition other closely allied products are included, chief among which are abrasives, gypsum, and lime. Few people realise the gigantic importance of these ceramic industries. The products of the three major divisions alone (clayware, glass, and cement) aggregate over 400,000,000 dols. per annum. In the earlier days the Society consisted of one main organisation only. With increased activities and enlargement in its scope of usefulness it became necessary to organise Local Sections, of which there are now ten in

existence, and four Student Branches. The publication work of the Society has, up to the present time, been confined to the issuing of the annual volume of *Transactions*. This has shown continuous growth from a very small beginning, and the 1917 volume comprises 707 pages of well-edited contributions. The American Ceramic Society's *Transactions* have for many years been known turoughout the world as the standard reference books on the silicate industries. The remarkable gr wth in strength and influence of the Society has made it essential that periodical publication of the researches and other activities of the Society's members be undertaken, and the monthly *Journal of the American Ceramic Society* is the logical result. The first number is a very attractively prepared journal of 72 pages. It is well edited and well printed on good paper. It contains, beside editorials and accounts of meetings of Local Sections, papers on "Kaolin in Quebec," "Special Pots for the Melting of Optical Glass," "The Effect of Gravitation upon the Drying of Ceramic Ware," &c. Membership of the Society is open to anyone interested in any branch of the ceramic industries. All members receive the journal gratis; to non-members the subscription price is 6 00 dols. per year (12 issues) payable to the Secretary in advance.

Alunite in Canada.—A deposite of alunite occurs on Kyuquot Sound on the west coast of Vancouver Island, British Columbia, Canada. The mineral is of the sodic variety known as natro-alunite. It is mixed with quartz, and a small amount of sericite and diaspore the natro alunite forming from 20 to 45 per cent of the mixture. Pyrite is disseminated through portions of the rock. The pyritiferous portions are bluish grey in colour, and are found chiefly near sea-level or as small cores in reddish to white rocks, which occur above ground-water level. The deposit has an area of 4½ acres, and contains above sea-level about 600,000 tons. Following are analyses of the rock, the first being the pink to white variety and the second being the bluish grey variety:—

	1.	2.
SiO_2	48·82	62·70
Al_2O_3	19·08	12·68
Fe_2O_3	0·07	1·40
FeS_2	—	2·69
MgO	—	0·05
CaO	—	0·20
Na_2O	2·74	1·09
K_2O	4·40	2·10
H_2O	7·00	7·15
SO_3	17·32	7·06
S..	0·57	2·88
	100·00	100·00

Further information about the deposit can be obtained from the Geological Survey, Ottawa, Canada.

Quantitatixe Estimation of Acetic, Propionic, and Butyric Acids.—R. D. Crowell (*Journ. Am. Chem. Soc.*, 1918, xl., 453).—The methods hitherto proposed for the separation of the acids of the acetic series have not afforded very satisfactory results; the solubilities of barium acetate, propionate, and butyrate in 97 per cent alcohol are too close to one another to permit of a separation of the three acids by this means. The respective solubilities per 100 cc. were determined with the following results:—Acetate, 0 0723 grm.; propionate, 0·1631 grm.; butyrate, 0 17 grm. The components of a mixture of any two acids may be estimated from determinations of the total acidity and the dry weight of the salts, and this principle has been applied in conjunction with a method in which the mixture of the three acids has been split up by selective solubility between an organic solvent and an aqueous salt solution. Out of various organic solvents studied, kerosene oil has been selected as the solvent for the butyric and propionic acids, and a saturated solution of calcium chloride with a little potassium chloride (20 grms. per litre) as the solvent for the acetic acid. The error involved by imperfect salting out of the butyric acid is determined and applied in the form of a correction factor. The accuracy of the method depends largely on the proper desiccation of the salts. The barium salts, especially if much propionate is present, are not satisfactory; the best results are obtained with the sodium or potassium salts, weighed in squat-shaped weighing bottles (60 mm. × 30 mm.) after heating for twelve hours at 200° C. The method of procedure is as follows:—An amount of the sample equivalent to about 7·5 grms. of acid is diluted or concentrated to 250 cc.; this is the standard concentration of working. Fifty cc. of the solution are measured out into a precipitating jar, 2·5 cc. of 50 per cent sulphuric acid are added and sufficient solid silver sulphate to precipitate all the chlorides present. The mixture is stirred with an electric stirrer, and should show, on testing, an excess of silver. It is filtered, and 25 cc. of the filtrate are distilled with 20 cc. of 33 per cent phosphoric acid in the usual manner for total volatile acids. Distillation is carried on until the residue amounts to 20 cc., and repeated three times with the addition of 20 cc. of carbon dioxide-free water each time. The distillate is titrated with N/4 sodium hydroxide, and the neutral liquid is boiled down to about 8 cc. and transferred to a tared weighing bottle in which it is evaporated to dryness on the steam-bath and then dried at 220° C. for twelve hours and weighed. The total acidity, expressed as sodium acetate, subtracted from the total salt weight, gives the weight of total CH_2 groups, which, multiplied by 4·2, gives the quantity per 100 cc. of the sample solution. Another portion of the standard sample (150 cc.) is treated as before for the removal of chlorides; 100 cc. of the filtrate are distilled with 20 cc. of phosphoric acid, as before, for total volatile acids. The distillate is titrated with N/4-barium hydroxide, and the solution is evaporated to a volume of 5·8 cc. The concentrated liquid is then acidified with N/4 hydrochloric acid equivalent to the titration value. The acid liquid is transferred to a 300 cc. separating funnel, and the flask rinsed out with two portions of 25 cc. of the salting solution and two portions of 25 cc. each of filtered kerosene. On thorough shaking, the butyric acid, together with some of the propionic, enters the kerosene layer. The salt solution is drawn off, and the kerosene washed with a further 10 cc. of salt solution. The *kerosene in the separating funnel is treated with 150 cc.* of carbon dioxide-free water, and the whole is titrated with N/4 barium hydroxide with frequent shaking. At the neutral point the aqueous solution is drawn off into a 250 cc. flask and diluted to the mark with washings of the kerosene. The whole solution is treated with 12·5 cc. of 50 per cent sulphuric acid and 3 grms. of solid silver sulphate, and 200 cc. are distilled with 40 cc. of phosphoric acid for volatile adids as before. The distillate, titrated with N/4-sodium hydroxide, is evaporated, and the sodium salts are dried at 200° C. as before. The sodium propionate equivalent of the titration value, subtracted from the salt weight, gives the weight of CH_2 groups present as butyric acid in the distillate. This value, calculated in terms of 100 cc. of the standard sample, has to be corrected by a factor F determined by the analysis of known mixtures, the average value of F being 1·120. The corrected value for CH_2 groups due to butyric acid, subtracted from the total CH_2 groups found in the first operation, gives the CH_2 groups due to propionic acid, and the acetic acid is found by the difference between the total volatile acidity and the combined butyric and propionic equivalents. The method has been tested on mixtures of various proportions of the three acids, using the mean value for F given above, and affords useful results with an average error of 3·25 per cent.—*The Analyst*, May, 1918, xliii., No. 506.

Prevention of Accidents in Workshops, Factories, &c.—As a sequel to the Conference held in London in June last, at which it was decided to conduct throughout the country a campaign for the prevention of industrial accidents, an influential organisation has been formed comprising representatives of the Admiralty, Board of

Trade, Home Office, Local Government Board, and the Ministry of Labour, of leaders of Industry and Labour. The title of the new body is the British Industrial "Safety First" Association. Its first meeting was held at the Mansion House on October 31, when Lord Leverhulme occupied the Chair and was elected President. The Vice-Presidents include the Presidents of the Local Government Board and the Board of Trade, the Ministers of Labour and of Food, the Under-Secretary of State for the Home Department, Lord Aberconway, Rt. Hon. T. Richards, M.P. (South Wales Miners' Federation), Mr. W. A. Appleton (General Federation of Trades Unions), Lt.-Col. G. Harland Bowden, M.P., Sir Vincent Caillard (Vickers', Ltd.), Mr. C. T. Cramp (President, National Union of Railwaymen), Sir Kenneth Crossley (Crossley Bros., Ltd.), Mr. R. Dennison (Iron and Steel Trades' Confederation), Mr. C. Duncan, M.P. (Workers' Union), Sir John Jackson, Mr. W. Joynson-Hicks, M.P., Mr. E. Manville (President, Association of Chambers of Commerce of the United Kingdom), Major General the Hon. Sir Newton Moore, K.C.M.G., M.P., Sir Hallewell Rogers, G.B.E. (Chairman, Birmingham Small Arms Co., Ltd.), Mr. H. B. Underdown (President, Association of British Motor and Allied Manufacturers, Ltd.), and Mr. Robert Young (General Secretary, Amalgamated Society of Engineers). The Hon. Treasurer is Sir R. V. Vassar-Smith, Bart., D.L. Briefly stated, the policy of the Association is the formation in every industry of a "Safety First" Committee comprising representatives of Employers and Employees, and of Committees in the leading firms, to investigate the causes of accidents peculiar to the particular industry, and to discover and apply effective measures and safeguards to prevent the recurrence of similar accidents. As numerous avoidable accidents are due to carelessness, and thoughtlessness on the part of the employees, a comprehensive educational campaign is proposed to be conducted from Headquarters, and members of the Association will receive regular supplies of posters and literature designed to point out the known causes of avoidable injuries. A Home Office pamphlet recently issued states:—"In 1914, 969 persons were killed and 147,045 persons were injured by accidents in the factories and workshops of this country. If to these figures were added the accidents in mines, quarries, buildings and other constructional work, and railways the total would be much more than doubled. These figures represent an enormous loss to the nation, to the industries, and to the workers themselves. It is of the first importance to the country, both during the war and also during the period of reconstruction after the war, that this great cause of waste and loss of efficiency in our industrial organisation should be as far as possible removed." It is contended that the maximum success in the alleviation of the suffering and sorrow which industrial accidents entail, as well as the saving, and the utilisation for better purposes, of the huge sums of money which would otherwise be paid as compensation, or represent losses of workers' wages, would be achieved at the minimum cost of industry and labour combined to co-operate with the Association in the prosecution of the industrial "Safety First" campaign. Applications for membership of the British Industrial "Safety First" Association should be addresed to the Hon. Secretary, pro. tem., Mr. H. E. Blain, at the temporary offices of the Association, 31, Westminster Broadway, London, S.W. 1.

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THE CHEMICAL NEWS

VOL. CXVII., No. 3062.

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THE recent paper restrictions have compelled us to publish only fortnightly instead of weekly for a time, but we are now glad to be able to announce that we are to be allowed a further supply of paper, which will enable us to revert to weekly publication in the near future.

Beginning with No. 3064, to be published on January 3, 1919, the CHEMICAL NEWS will again appear weekly, and the dates of expiration of subscriptions will be adjusted accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their subscription periods. The price will remain unaltered, viz., £1 for fifty-two numbers, or *pro rata*.

DOG-FISH LIVER OIL.

By A. CHASTON CHAPMAN, F.I.C.

In connection with a tehnical inquiry on which I am engaged it has been necessary to submit the liver oil of the dog-fish to a chemical examination, and as very few references to this oil occur in chemical literature, I have thought that it might be of interest to place some of my results on record.

The common dog-fish (*Squalus acanthias*)—sometimes less correctly designated *Acanthias vulgaris*—occurs in very large numbers off various parts of our coast at certain periods of the year. It is readily distinguished from other species by the sharp spines (triangular in section) which occur in front of each dorsal fin, the one before the second dorsal being longer and more conspicuous than the other. It is owing to these spines that the dog-fish is frequently known as the "spur" or "piked" dog-fish.

The dog-fish is viviparous, the mature female producing each season about ten young, each from 9 to 10 inches in length. It is usually found near the coasts during the warmer months, and during the winter it retires into deeper water. The dog-fish varies somewhat considerably in size, occasionally attaining a length of about 4 feet. In weight it varies from 3 to 8 or 10 pounds.

For the purpose of my inquiry a considerable number of the fresh livers were submitted to me, and also two of the freshly caught fish. One of these weighed about 3 pounds and the other nearly 6 pounds, the liver of the former weighing 4½ ounces and that of the latter 6 ounces. The largest liver which came into my hands weighed 7 ounces. When the fresh livers were finely minced and steamed, a quantity of oil corresponding with from 40 to 50 per cent of the weight of the livers was obtained, consisting of a pale yellow oil having a slight fishy but not unpleasant odour. When cooled down to about 10° C. it became semi-solid, owing to the separation of a crystalline substance, but regained its transparency on warming.

The following results obtained by Thomson and Dunlop are quoted by Lewkowitsch ("Chemical Technology and Analysis of Oils, Fats, and Waxes," ii., 370):—

Specific gravity	0·9179
Saponification value	169·7
Iodine value	126·4
Butyro-refractometer rotation—	
At 25° C.	71·2
At 40° C.	62·5
Unsaponifiable matters	8·4 per cent
Specific rotatory power $(\alpha)_{3}$	−1·67

Two specimens of oil prepared in my laboratory from different batches of liver gave on examination the following results:—

	"No. 1."	"No. 2."
Specific gravity (15°/15° C.)	0·9175	0·9186
Saponification value	161·0	168·3
Iodine value (Wijs)	123·3	123·0
Free fatty acids (as oleic acid)	0·33 per cent	0·42 per cent
Unsaponifiable matters	32·94	9·48
Refractive index at 20° C.	1·4755°	1·4749°
Brominated glycerides insoluble in ether	19·25 per cent	24·95 per cent
Optical activity (100 mm. tube, sodium light)	—	−1·45°

Both the above samples of oil had been cooled to −10° C. for a considerable time and filtered through fine linen, in order to remove the crystalline matter which separated. This was found to contain only 7·3 per cent of unsaponifiable matters, so that it evidently consisted chiefly of glycerides.

It will be seen that the results for the "No. 2" oil agree very closely with those obtained by Thomson and Dunlop. The percentage of unsaponifiable matters in the "No. 1" oil is, however, very much higher, and assuming, as I have every reason to believe, that all the livers submitted to me were from the spur dog-fish, it would appear to indicate that the percentage of unsaponifiable matter in this oil is subject to wide variations. At the present moment the precise physiological relationship between unsaponifiable matters and glycerides in the livers of fish is not known; but as these two classes of compounds must be in a constant state of change, and are doubtless dependent on the age and condition of the individual fish, such differences are only what one might expect to find.

I am taking steps to obtain a sufficient quantity of the unsaponifiable matter of this liver oil, and hope to be able to submit it to a thorough examination, chiefly with the object of ascertaining whether it contains the hydrocarbon "spinacene," which I have shown to be present in the liver oils of certain fish belonging to the same natural family. Obviously, however, it cannot contain much.

These two samples gave the following colour reactions:—

One drop of a mixture of 1 volume of oil with 1 volume of carbon disulphide was introduced into concentrated sulphuric acid.	Deep violet, rapidly turning brown.
One drop of strong sulphuric acid was added to a solution of 1 drop of the oil in 1 cc. of chloroform.	Pale blue, becoming deep reddish violet on stirring, then gradually fading to reddish brown.
Two cc. of a solution of sodium phospho-molybdate acidified with nitric acid were added to a solution of 1 cc. of the oil in 5 cc. of chloroform.	The chloroform layer acquired a pale green colour.
Ammonia was added to the preceding solution.	The green colour became bluish violet.

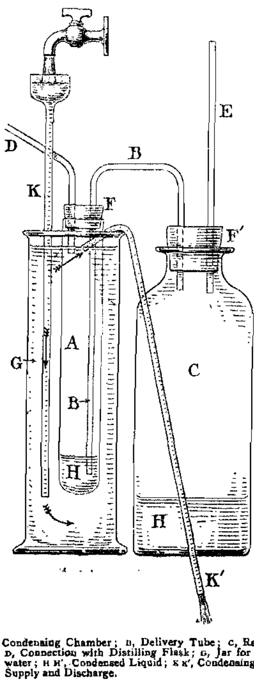
Three drops of fuming nitric acid were cautiously added to about 10 drops of the oil.	Purple, changing on stirring to dark reddish brown.

—*The Analyst.*

A SIMPLE AND EFFICIENT CONDENSER.

By R. HOWDEN, B Sc.

The accompanying sketch represents a condensing arrangement which can easily be constructed by anyone from ordinary laboratory materials. A is a tube closed at one end, 1 inch in diameter and 8 or 9 inches in length. It is fitted with a stopper, F, into which are inserted the narrow tubes B and D, and is immersed in a jar, G, of cold



A, Condensing Chamber; B, Delivery Tube; C, Receiver; D, Connection with Distilling Flask; G, Jar for cooling water; H H', Condensed Liquid; K K', Condensing Water Supply and Discharge.

water. The tube D is connected with the distilling flask by an air-tight joint. B reaches nearly to the bottom of A, and connects with the receiver C. A stream of cold water is kept running as shown into G, and when it reaches the top of the jar it siphons over by the bent tube K without overflowing the lip of the jar.

As soon as a small quantity of liquid condenses at H the condensing chamber is sealed by it, and it is impossible for the smallest quantity of vapour to escape condensation. The pressure in A forces the liquid by the tube B into the receiver C, which is open to the atmosphere only by the small-bore tube E in order to minimise loss of volatile liquid by evaporation.

This arrangement has been proved very efficient in the distillation of ether residues.

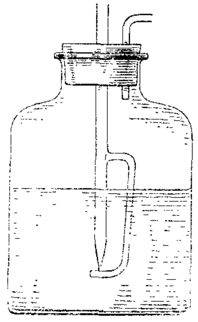
GAS BUBBLER FOR GAS ANALYSIS.

By O. D. BURKE.

In estimating sulphur dioxide in gases the general method is to pass the gases containing SO_2 to be estimated through a solution of either N/10 iodine or N/100 iodine. The apparatus employed being a flask or bottle connected to an aspirating bottle containing water, the displacement of which is the measure of the gas passed through the apparatus.

The bottle containing the iodine solution is fitted with a narrow glass tube dipping into the iodine solution, or else a tube blown out at end to a globular shape and perforated with fine pin holes, which tend to break up the gas stream into small bubbles.

This method has serious drawbacks, especially in the



hands of careless juniors, where gases which are to be estimated are under pressure. The chief cause of trouble is the tendency to rush the gas through the iodine solution too quickly for the interaction between the SO_2 and iodine to be complete, with consequent erroneous results. A variation of as much as 1 per cent can be made quite easily by careless manipulation by two different juniors. To overcome this difficulty I had a bubbler made (see sketch).

A narrow glass tube is drawn out at one end into a very fine capillary, which is ground level at the point or end. Another glass limb is fused on to the straight limb, and extends downwards to just beneath capillary, where it is flattened out and the top surface ground. The capillary is made to fit tight on the flat ground surface of the second limb.

In this way the gas passing through the capillary tube is broken up into very fine bubbles no larger than a pin point; also the space is so restricted for the passage of the gas that no rushing through can take place, and the time

interval for the passage of a certain volume of gas is identical in all cases; thereby with just ordinary care ensuring extreme accuracy.

ARSENITE TITRATIONS OF PERMANGANATE SOLUTIONS.

By ALOKE BOSE, Assoc.Inst.M.M. (Lond.).

When steel is dissolved in dilute nitric acid, and then boiled with the usual quantities of silver nitrate and ammonium persulphate, and the permanganic acid thus formed titrated with a standard solution of sodium arsenite or arsenious acid, it is found the quantity of sodium arsenite or arsenious acid required to titrate the permanganic acid is just about two-thirds of that required theoretically. In other words, the factor obtained for manganese in practice is about one and a-half times as much as the theoretical factor.

The present author came across the above curious chemical phenomenon about three years ago, and though numerous experiments were carried out no explanation could be found, and so the above facts with some figures obtained were communicated to Mr. F. Ibbotson, of Sheffield, on June 15, 1917. Postal communication between India and England is uncertain in these times, and it is quite possible the letter did not reach its destination. Anyhow, no reply came, but an extract of a paper on the subject in the Chemical News by Mr. Ibbotson appeared in the *Journal of the Society of Chemical Industry* on May 31, 1918. With some difficulty a copy of the paper in the Chemical News (1918, cxvii., 157) was obtained by the present author.

It has been remarked in that paper that the phenomenon above referred to was not generally known, but no serious attempt has been made to explain the cause of it.

There are three points that have been particularly noted by the present author, and they will be discussed in due course.

1. "The fact, however, that when sodium arsenite is used in the titration of permanganic acid containing free nitric acid the 'oxygen exchange' is not quantitatively expressible by—

$$2Mn_2O_7+5As_2O_3 \rightarrow 4MnO+5As_2O_5, \&c."$$

2. "From these results it appears that solutions of sodium arsenite have a reducing value approximately 33 per cent in excess of the true value, when added to solutions of permanganate acidified with nitric acid. This result is obviously due to the formation of manganic compounds, . . ."

3. "The constancy of the ratio of the volume of permanganate to that of arsenite in the second series points to the existence in the solution of a definite compound."

With regard to the first point it might be pointed out that all the errors of the method the present author can think of tend to be in the direction opposite to that found in practice:—

(*a*) During the sodium arsenite titration the colour of the permanganate comes back,

(*b*) If the free nitric acid in the permanganate solution at all oxidises the arsenite solution.

According to either of the above more arsenite will be required in practice than that required theoretically.

It was the second point, *i.e.*, less arsenite being required in practice, that was noticed by the present author, and as no explanation could be found it was communicated to Mr. Ibbotson.

With regard to the third point, it is not stated whether the "definite compound" exists in the arsenite solution or in the permanganate.

All these points will be discussed more thoroughly after some of the results obtained by the present author are given.

I. (*a*) When steel is dissolved in ammonium persulphate and water only a clear pink solution is not obtained even when 10 grms. of the persulphate is used for 0·2 grm. of steel.

(*b*) If now 10 cc. of 5E nitric (made by adding 690 cc. H_2O to 310 cc. strong nitric) be added to the above solution a clear green solution is obtained. If then 5 cc. of silver nitrate (8·5 grms. in 2 litres) be added and boiled a clear pink solution of normal depth of colour is obtained; *i.e.*, it takes the usual quantity of arsenite to titrate (0·33 grm. $As_4O_6+Na_2CO_3$, 2 grms., boiled with H_2O and made up to 1 litre).

II. When 0·2 grm. steel (0·65 per cent Mn) is dissolved in 6 to 8 grms. of ammonium persulphate, water, and 5 cc. silver nitrate, a clear pink solution of normal depth of colour is obtained.

III. (*a*) When 0·2 grm. of steel is dissolved in 10 cc. 5E nitric, and then ammonium persulphate (4 to 15 grms.) be added and boiled, no pink coloration is obtained. If now the usual quantities of silver nitrate and ammonium persulphate be added and boiled, pink colour to the normal extent is produced.

III. (*b*) If 0·2 grm. of steel is dissolved in 10 cc. of 5E nitric, and then boiled with 5 cc. $AgNO_3$ and about 4 grms. ammonium persulphate, after dilution (the usual method) normal pink colour is produced. This can be discharged by adding an excess of 5E nitric to the boiling solution, but the colour again returns to its normal extent on standing.

IV. When 0·2 grm. of steel was dissolved in 10 cc. 5E nitric, with varying quantities of silver nitrate (from 5 cc. to 20 cc.) and 4 grms. ammonium persulphate, pink colour to the normal extent was produced in each case.

V. When 0·2 grm. of steel was dissolved in 10 cc. 5E nitric, and then boiled with the usual quantities of silver nitrate and ammonium persulphate, and the normal colour thus produced titrated with standard solutions of ferrous ammonium sulphate and permanganate (as by the bismuthate method), after dilution 0·66 per cent Mn was found in a 0·65 per cent steel. This should show that all the manganese is oxidised to the condition of permanganic acid.

VI. A standard solution of potassium permanganate was prepared so that 12 cc. of it was equal to 0·66 per cent Mn.

∴ 2·4 cc. of it = 0·66 per cent Mn (when calculation is made as on 0·2 grm.).

VI. (*a*) Took 0·1 grm. steel (=0·325 per cent Mn), and 1·2 cc. $KMnO_4$ solution (=0·33 per cent Mn) with 10 cc. 5E nitric, 5 cc. $AgNO_3$, ammonium persulphate, &c.

(*b*) Took 2·4 cc. $KMnO_4$ (=0·66 per cent Mn) and the usual quantities of 5E nitric, $AgNO_3$, persulphate, &c.

In each case pink colour to the normal extent was produced.

The quantities of steel and $KMnO_4$ were then made to vary, but invariably the same factor was obtained.

(*c*) If 10 cc. 5E nitric, 5 cc. $AgNO_3$, and about 4 grms. persulphate be boiled with H_2O till clear, a drop of $KMnO_4$ (N/20) produces a pink colour.

VII. A standard solution of H_3AsO_3 was prepared (0·33 grm. per litre).

This solution was tested against iodine and found to be of same strength as N/150.

A normal solution of $HMnO_4$ = 11 Mn/litre.

" " " H_3AsO_3 = 49·48 As_4O_6/litre.

∴ 49·48 As_4O_6 = 11 Mn.

∴ 0·33 As_4O_6 (= 1000 cc) = 0·073 Mn.

∴ 1 cc. = 0·000073 Mn = 0·0073 per cent Mn (on unit weight).

∴ 1 cc. = 0·000073 Mn = 0·036 per cent Mn (calculated on 0·2 grm.).

In practice 1 cc. H_3AsO_3 = 0·054 per cent Mn (on 0·2 grm.), (see VIII.); *i.e.*, the factor in practice is one and a-half times the theoretical factor.

The As_4O_6 solution (theoretically and against iodine) = N/150.)

But against permanganate—

12 cc. As_4O_6 solution = 2·4 cc. $KMnO_4$.
∴ 1 cc. „ „ = 0·2 „ „

But $KMnO_4$ = N/20.
∴ As_4O_6 solution = N/100 (whereas against iodine and theoretically = N/150).

VIII. Take 0·2 grm. steel (0·65 per cent Mn) in 10 cc. 5E, and usual quantities of $AgNO_3$, persulphate, &c. Pink colour to the normal extent thus produced was titrated with standard H_3AsO_3 solution. (Factor = 0·054).

IX. Take 0·2 grm. steel in dilute H_2SO_4, add $AgNO_3$, persulphate, &c. Normal pink colour was produced.

X. Take 1 grm. steel and treat as for bismuthate method, make up to 250 cc., and then take 50 cc. (= 0·2 grm.), and titrate with sodium arsenite. Normal pink colour was produced.

XI. If a solution that has been treated as for persulphate method be allowed to stand long enough after titration, so long as there is a sufficient excess of persulphate, pink colour to the normal extent returns, and may again be titrated and the same figures obtained.

It will be seen from the above experiments that the different elements used in the persulphate method were eliminated so as to find the interfering element, if any. But none was found. Some of the factors were found to be slightly above and some slightly below 0·054, but none of them in any way approached the theoretical figure 0·036.

We shall now return to the discussion of the paper by Mr. Ibbotson as sketched out in the beginning of this paper.

In 1 and 2 special mention has been made of permanganate solution in "free" nitric acid, as if that acid were in any way responsible.

The nitric acid theory was advanced to the present author by Dr. P. C. Ray, of the University College of Science, Calcutta, as early as April, 1917, but Experiments II. and IX. should clearly show that that acid cannot be responsible.

If nitric acid does have any action, then sulphuric acid, or ammonium persulphate plus silver nitrate, must have a similar action and to the same extent. In that case the action must either be a reducing one on permanganic acid, and hence make the latter use less sodium arsenite than is theoretically required, or it must have a reducing action on the sodium arsenite (somewhat similar to that of H_2O_2 on permanganate).

Neither of the above explanations can hold good.

If HNO_3 reduces a part of the permanganate then (1) it is not possible to titrate the full amount by ferrous ammonium sulphate (see V.); a permanent pink colour would probably not be produced with traces of permanganate —see VI. (*c*); (3) titration in solutions where no HNO_3 is used should give factors approaching the theoretical.

If HNO_3 has a reducing action on the sodium arsenite, which in itself is very difficult to conceive, then when no HNO_3 is used the theoretical factor should be obtained, or when varying quantities of HNO_3 be used (see III. *b*) different factors should be obtained.

The above should clear the first point that the "free" nitric cannot be responsible for a higher factor in practice.

With regard to the second point, Mr. Ibbotson says that the result is obviously due to the formation of manganic compounds. But what these compounds are and whether they are formed during the oxidation or titration is not clearly stated.

If during the oxidation, then these compounds must be in a lower state of oxidation than $HMnO_4$, and also the same compounds are formed during the bismuthate oxidation, as in both cases the same figures are obtained (see X.). This is not possible. If during the titration, then the manganic compound would come down and render the solution turbid, and a second titration as in Experiment XI. would not be possible.

(N.B.—If a solution with HNO_3 be over-boiled in the first instance a precipitate—probably of manganic oxide—comes down, and is not cleared even when boiled with $AgNO_3$ and persulphate).

As for the third point, if the "definite compound" exists in the sodium arsenite then it also exists in the arsenious acid solution. This is not possible, as pure arsenious acid cannot contain any other compound.

On the other hand, if the "definite compound" exists in the permanganate then it means that only a part of the manganese is oxidised to the condition of $HMnO_4$. This also, as pointed out above, is not possible. If it is possible then all the formulæ for the bismuthate as well as for the persulphate methods want overhauling.

Some other explanation must be given. It is quite possible that some complicated reactions take place during the titration, as up to that point it is quite clear from ferrous ammonium sulphate titrations that all the manganese is in the condition of permanganic acid, and the experiments without the nitric acid should show that that acid cannot in any way be responsible for the higher factor obtained in practice.

The Government Laboratory,
Sakchi, via Kalimati, B.N. Rly., India,
August 29, 1918.

NOTES ON ISOTOPIC LEAD.

By FRANK WIGGLESWORTH CLARKE,
United States Geological Survey, Washington.

One of the most remarkable discoveries in the field of radioactivity has been the fact that the elements of highest atomic weight, uranium, and thorium, are unstable, and undergo slow transformations into other substances, especially into helium and lead. The lead thus produced is identical with normal lead in its spectrum and its distinctively chemical properties, but different in its atomic weight; and this difference, which is thoroughly established, is of peculiar significance. The purest lead from uranium minerals has an atomic weight fully a unit lower than that of ordinary lead, while that from thorium minerals is nearly a unit higher. These are the extreme differences, so far as the present evidence goes; but the actual determinations of the atomic weights of these *isotopes* of lead show wide variations due to differences between the minerals from which the lead was obtained. Furthermore, these isotopes differ from ordinary lead in specific gravity; one being lighter and the other heavier than ordinary lead, these differences being proportional to the variations in atomic weight. Consequently the three kinds of lead have the same atomic volume, and occupy the same place in the periodic classification of the chemical elements.

Ordinary or *normal* lead differs from isotopic lead in one important respect, namely, its atomic weight is constant, and the actual determinations vary only within the limits of experimental uncertainty. This constancy was established by Baxter and Grover (*J. Am. Chem. Soc.*, 1915, xxxvii., 1027), who studied lead from a number of distinct sources. Their material was derived from four mineral species, galena, cerussite, vanadinite, and wulfenite, and also from commercial lead nitrate. Furthermore, the minerals examined came from seven widely separated localities; two from Germany, and one each from Australia, Missouri, Idaho, Washington, and Arizona. The lead in each case was carefully purified, and converted into chloride, with which the determinations of atomic weight were made. The method of determination was the standard method long in use at Harvard, and based upon large experience and the most thorough technique. The values found for the atomic weight are shown in the following table:—

Source.	Atomic weight of lead.
Commercial nitrate	207·21
Cerussite, New South Wales	207·22
Cerussite, Eifel Mountains, Germany	207·20
Galena, Joplin, Missouri	207·22
Cerussite, Wallace, Idaho	207·21
Galena, Nassau, Germany	207·21
Vanadinite and wulfenite, Arizona	207·21
Galena, Metalline Falls, Washington	207·21

A series of analyses of lead bromide gave values practically identical with these.

This evidence as to constancy of atomic weight is conclusive, but it has also been confirmed by three investigations by Richards and his colleagues in this country, and by Hönigschmid in Vienna. These later determinations were made as checks upon determinations of the atomic weight of isotopic lead derived from uranium minerals.

In 1914 Richards and Lembert (*J. Am. Chem. Soc.*, 1914, xxxvi., 1329) published their determinations of the atomic weight of isotopic lead. Their results may be summarised as follows:—

Source.	Atomic weight.
Lead from Ceylonese thorianite	206·82
Lead from English pitchblende	206·86
Lead from Colorado carnotite	206·59
Lead from Bohemian pitchblende	206·57
Lead from North Carolina uraninite	206·40

Two years later another series of determinations by Richards and Wadsworth appeared (*J. Am. Chem. Soc.*, 1916, xxxviii., 2613). The average results obtained were as follows:—

Source.	Atomic weight.
Australian carnotite	206·375
Colorado carnotite	207·004
Bröggerite, Norway	206·122
Cleveite, Norway	206·085

Still another series of six determinations by Richards and Hall (*J. Am. Chem. Soc.*, 1917, xxxix., 531) on lead from Australian carnotite gave a mean value for the atomic weight of Pb = 206·415.

In a preliminary study of lead from Bohemian pitchblende, Hönigschmid (*Zeit. Elektrochem.*, 1914, xx., 457) found values for the atomic weight ranging from 206·719 to 206·749. In a later investigation by Hönigschmid and Horovitz (*Monatsh. Chem.*, 1915, xxxvi., 355), lead was extracted from three different minerals, namely, the purest Joachimsthal pitchblende, a crystallised uranium ore from Morogoro, German (?) East Africa, and bröggerite from Norway. The average values for the atomic weight were as follows:—

Source.	Atomic weight.
Pitchblende	206·406
The Morogoro ore	206·042
Bröggerite	206·067

All of these determinations of atomic weight, including those of Baxter and Grover on normal lead, were made by the same method, the same care as to purity of materials, and the same refinements of technique. Even Hönigschmid, now in Vienna, has worked on atomic weight determinations with Richards, and so was familiar with the best procedure. The results obtained are therefore strictly comparable.

For the atomic weight of thorium lead the data as yet are scanty, and based entirely upon material derived from Ceylonese thorite and thorianite. From the specific gravity of thorite lead Soddy (*Nature*, 1915, xciv., 615) has deduced the atomic weight of Pb = 207·64; and Hönigschmid (*Chem. Abst.*, 1917, xi., 3173; from *Physik. Zeit.*, 1917, xviii., 114) from analyses of lead chloride prepared from Soddy's original material has found Pb = 207·77. This value, however, is probably too low for the true thorium lead, for the reason that thorite, with a preponderant proportion of thoria, also contains some uranium. The thorite lead, therefore, must contain both isotopes, but with the higher one in much the largest quantity. The thorianite lead studied by Richards and Lembert had a still lower atomic weight, namely, Pb = 206·82, which shows that this variety of the metal is not of uniform character.

That the atomic weight of uranium lead is extremely variable has already been shown. In order to interpret this variability its sources must be studied both geologically and mineralogically. On the geologic side of the question the uranium ore can be divided into three principal classes, which are sharply distinct. The definitely crystallised varieties of uraninite occur in coarse pegmatites, associated with felspar, quartz, mica, beryl, and other minor accessories. The massive pitchblende is found in metalliferous veins, together with sulphide ores of copper, lead, iron, zinc, and so forth. As for carnotite, that is a secondary mineral, found commonly as an incrustation on sandstone, and often also upon fossil wood. There may be other modes of occurrence, but these are the most distinctive.

In chemical composition the uraninites, as shown by Hillebrand's splendid series of twenty-one analyses, fall into well defined groups (*Washington, U.S. Geol. Survey, Bulls.* 78 and 90; also in *Bull.* 591, p. 366; Hillebrand discusses the mode of occurrence of these minerals, much as I have done). All contain uranium oxides, ranging from 65 to 90 per cent, the low figures, however, representing altered material. The crystallised, pegmatitic uraninites are characterised by their content in thoria and other rare earths, from 6 or 7 up to as much as 11 per cent. They also contain subordinate proportions of lead and the largest amount of helium. In bröggerite and cleveite, however, lead is in excess of thoria. The massive pitchblendes, on the other hand, contain no thoria, usually much lead, and little or no helium. That from Black Hawk, Colorado, is exceptional. It is intimately associated with sulphide ores, but contains little lead, and zirconia instead of thoria. Carnotite, which is quite unlike uraninite, is essentially a vanadate of uranium and potassium, with very little lead and no helium. It is, however, an important source of radium.

It is now possible to correlate, at least roughly, the composition of the several minerals with the determinations of the atomic weight of uranium lead, although for a perfect comparison we should have analyses of the actual ores from which the various samples of lead were obtained. On theoretical grounds it is supposed that the true atomic weight of uranium lead is not far from 206, and only determinations which approach that value are those which represent crystallised uraninite, including the varieties bröggerite and cleveite. These minerals all contain helium, so that there seems to be a relation between the formation of these two degradation products of uranium. The minerals also contain thorium, which would tend to raise the atomic weight and so complicate any discussion of the figures. The most brilliantly crystallised uraninite, that from Branchville, Connecticut, contains 85 per cent of UO_3+UO_2, with about 7 per cent of ThO_2, 4·35 per cent of PbO, and a maximum, 0·4 per cent of helium. The atomic weight of lead from that source, unfortunately, has not been determined; and it is doubtful whether material enough for accurate investigation could be obtained.

The other determinations of the atomic weight of uranium lead give values much above 206, and even approaching 207. This is especially true of the lead from pitchblende, which contains no thorium and little if any helium. Its association with sulphide ores, however, leads to the suspicion that it may contain ordinary lead, perhaps in the form of occluded or dissolved galena. The atomic weight of the lead derived from it would, therefore, be that of a mixture, and not of the isotope alone.

The carnotite lead would also seem to be a mixture, but of what kind is not clear.

The atomic weight of isotopic lead now seems to be a complex of at least three quantities, namely, the atomic weights of normal lead, uranium lead, and thorium lead, in varying proportions. Since the atomic weight of the two isotopes differ from that of normal lead in opposite directions it is difficult to determine in any particular case the relative proportions of the three modifications of the element. It has been suggested that normal lead is a balanced mixture of its isotopes; but the constancy of the atomic weight of the ordinary metal seems to negative that supposition. In order to fulfil this condition it would be necessary that the isotopes should always commingle in equal or at least definite proportions; which is extremely improbable. The apparent variations in the atomic weight of lead, as shown in the older determinations, are due to varying methods, imperfect technique, different values for the atomic weights of the other elements with which that of lead is compared, and experimental errors. The modern determinations, which I have already cited, are the only ones that are strictly comparable.

The suggestion that the lead contained in uranium ores is partly normal lead is not new. It has been advanced by other writers (see Joly, *Phil. Mag.*, 1911, [6], xxii., 354, and Becker, *Bull. Geol. Soc. Am.*, 1908, xix., 134), but the variable atomic weight of uranium lead gives the supposition a decided emphasis. It now acquires new importance because of its bearing upon certain attempts to use the ratio between uranium and lead in uranium minerals as a datum for computing the age of the earth. For this purpose the ratio has been employed by Boltwood (*Am. J. Soc.*, 1907 [4], xxiii., 86), who calculated it from almost all the trustworthy analyses of uraninite and its nearly allied species, and from it deduced their ages. These ages differ exceedingly. For a crystallised uraninite from Connecticut he found the age to be 410,000,000 years, and for Ceylonese thorianite 2,200,000,000 years. These calculations, and others, like them, involve two assumptions; first, that the rate of change from uranium to lead is accurately known, and, secondly, that all the lead was of radioactive origin. The latter assumption is now seen to be extremely doubtful, for the varying atomic weights prove that more than one kind of lead must be considered. Thorium lead especially must be taken into account, for many uraninites contain it, and in thorianite the percentage of thoria is more than five times that of uranium oxide. The ratio of lead to its parent elements is therefore much less than Boltwood assumed, and the calculated age of thorianite is vastly reduced. Boltwood, however, doubted the derivation of lead from thorium, a fact which was not definitely known at the time his paper was written. The evidence of the atomic weights is also much later.

Furthermore, the doubtful applicability of Boltwood's method to chronological measurements has been shown by G. F. Becker (*Bull. Geol. Soc. Am.*, 1908 [4], xix., 134; see also Zambonini, Rome, *Atti. Acc. Lincei*, 1911 [5], xx., part 2, 131), who applied it to the analyses of rare-earth minerals from one locality in Llano County, Texas. The figures given by Becker are as follows:—

Mineral.	Analyst.	Calculated age in years.
Yttrialite	Mackintosh	11,470,000,000
Yttrialite	Hillebrand	5,136,000,000
Mackintoshite	Hillebrand	3,894,000,000
Nivenite	Mackintosh	1,671,000,000
Fergusonite	Mackintosh	10,350,000,000
Fergusonite	Mackintosh	2,967,000,000

These ages differ enormously, even between two analyses of the same mineral. This evidence, taken together with the evidence from the atomic weights, seems clearly to show that the uranium-lead ratio is not applicable to the determination of the age of minerals. It is quite certain that not all of the lead in uranium ores is of radio-active origin. In pitchblende, for example, which contains no thorium, the determinations of atomic weight range from 206·40 to 206·88, figures far in excess of the theoretical 206·00 which is assigned to pure uranium lead. Normal lead, perhaps in solid solution, must be present in such ores.

What, now, is the fundamental difference between normal lead and isotopic lead? The answer to that question must be largely speculative; but speculation is legitimate when its purpose is to stimulate future research. One difference at least may reasonably be assumed, namely, that normal lead is the product of an orderly evolution of the chemical elements; and that isotopic lead is a product of their decay. Creation is one process, destruction is the other.

Forty-five years ago (*Popular Science Monthly*, January, 1873) I ventured to suggest that an evolution of the elements had actually occurred. It was clearly indicated by the progressive chemical complexity of the heavenly bodies, from the chemically simple gaseous nebulæ, through the hotter stars and the sun, to the finished planets like our earth. At first, hydrogen and helium were the most abundant and conspicuous elements, then elements of higher atomic weight gradually appeared, and at the end of the process there was the chemical complexity of the earth, in which the free elements had in great part been absorbed and replaced by a multitude of compounds. On this basis hydrogen and helium seem to be the oldest of the known elements, while uranium and thorium are the youngest of all. Lead is older than uranium and thorium, for its lines appear in the solar spectrum, in which the other two elements have not as yet been recognised. Lead, however, is vastly more abundant than either uranium or thorium, and is more likely to have been originally their progenitor than their child.

Up to this point we have a reasonable interpretation of definite evidence, beyond this imagination must come into play. It is fair to assume that the process of evolution was extremely slow, and that each element was developed gradually and passed from an unfinished to a finished stage. The chemical atoms are now known to be extremely complex structures, each with an electropositive nucleus surrounded by electrons in rapid motion. That such a structure could have been developed instantaneously, with no previous preparation, is hardly probable, for the process was one of condensation, from lighter to heavier, and that, it would seem, must have required time. The process was one from relative simplicity of structure to relative complexity, and with the maximum condensation, as shown by uranium and thorium, a minimum of stability was reached. That is, so far as we now know, for less stable atoms may have been formed, to exist for a brief period and then vanish. Some of the radio-active elements which appear as products of the decay of uranium are of this kind. On that theme more later.

That the atoms of the elements above helium in the scale of atomic weights could not have been formed instantaneously is indicated by their structure. It has been shown that they are built up of smaller particles of electrons, and also in part, perhaps, of pre-existent helium. Such particles, approaching one another at first in irregular proportions, are supposed to have formed the atoms in question; but that exactly the right proportions for stability were found at once is hardly conceivable. There must have been a period of selection, in which the unavailable particles were discarded, probably to be used in other structures later. For each new chemical atom a definite balance between electro-positive and electro-negative particles was required, and also the establishment of a stable configuration. When these conditions were fulfilled the atom of an element was complete. As I have already said we can fairly assume that there was a distinct passage from an unfinished or incipient structure

to a finished one of permanent stability. Furthermore, as shown by the spectra of stars and nebulæ, the elements of relatively low atomic weight were first formed, and those of higher atomic weight came later. The older elements were also developed in the largest quantities, and are therefore the most abundant. The later elements are as a broad general rule much scarcer. This rule is not absolutely exact, but it expresses some well known general relations. The very simple and very stable primordial helium, however, is now relatively rare; but there is evidence to make us believe that it was largely consumed in building other elements. Its present observed emission by radium is evidence in favour of this supposition.

In this evolutionary hypothesis with its subsidiary speculations there is, I think, nothing incompatible with present knowledge. In matters of detail it is unavoidably incomplete; but notwithstanding its imperfections it bears very directly upon a consideration of the later phenomena of radio-active decay. Here the process of evolution is reversed and rapid changes take the place of slow ones. Furthermore, the normal elements are supposed to be veritable store-houses of potential energy; which in radio-active changes becomes partly kinetic. Radium, for example, gives forth heat continuously, and its rate of decay can be observed in the laboratory.

Through the investigation of radio-active transformations more than thirty new substances, elements or pseudo-elements, have been discovered. Some of these are extremely *evanescent, lasting only for seconds or even* fractions of a second; others are relatively long-lived. All of them, however, are more or less unstable, and change slowly or swiftly into other things. Some of them are metallic, like radium, polonium, and actinium; others appear as emanations which belong to the group of the chemically inert gases. One of these, helium, is continuously being generated from radium. Some, again, are isotopic with bismuth or thallium, and four of them are said to be isotopes of lead. These are Radium B, Thorium B, Actinium B, and Radium D. The first three are short-lived, and endure only for a few minutes or hours, but Radium D, also known as radio-lead, is assigned a probable life period of twenty-four years, and given theoretically an atomic weight not far from 210. In its chemical relations it cannot be distinguished from lead.

All four of these isotopes may have been present in uranium lead at the time of its formation, but it does not seem possible that even a trace of them could persist in the lead which is now extracted from uraninite or thorianite. They are therefore negligible in our consideration of the evidence which is now supplied by the study of the atomic weights, except in so far as they show the probable derivation of uranium lead and thorium lead from the two higher elements. The essential point is that all these varieties of lead are products of degradation, and in that respect differ fundamentally from the normal product of evolution. The thirty or more new substances which have been revealed to us by the study of radio-activity are all matter in a state of transition from instability towards some stable form, which may be lead, or bismuth, or thallium, or some other element which has not yet been recognised as an end-product of these mysterious changes. As these products are approached we have them in an incomplete condition, nearly but not quite identical with the permanent elements; this may be the character of isotopic lead. The fact that uranium lead is radio-active shows that it is still undergoing change, and that its atoms have not acquired the exact composition and configuration which give to normal lead its uniformity and stability. Whether or not the process of change can continue until normal lead is formed it is impossible for us to say.

The atoms of the chemical elements are, as I have already said, extremely complex, but their structure is not yet completely understood. To some part of each kind of atom its chemical properties and its spectrum are probably due. It is conceivable that this part may be the earliest to form, with its surrounding rings or envelopes at first not quite adjusted to permanent stability. With the final adjustment the isotopes as such should disappear, and the normal element be completed. This is speculation, and its legitimacy remains to be established. A careful comparison of the spectra of the elements from thallium up to uranium might furnish some evidence as to its validity. The spectrum of uranium, for example, may contain lines which really belong to some of its derivatives.

Note.—Since this paper was written, one by Prof. Barrell has appeared (*Bull. Geol. Soc. Am.*, 1918, xxviii., 745), in which the use of the uranium-lead ratio for determining the age of minerals is defended. There are also two papers by Holmes and Lawson (*Phil. Mag.*, 1914, [6], xxviii., 823; 1915, xxix., 682), and another by Holmes (*Proc. Geologist's Assoc.*, 1915, xxvi., 289), in which the same position is taken. There is evidently room for further discussion of the subject, but as yet I see no good reason to change my own views.—*Proceedings of the National Academy of Sciences*, June, 1918, iv., 181.

LAND FOR RECONSTRUCTION.

The Minister of Reconstruction, Dr. Addison, has issued for publication the first report of the Committee appointed under the Chairmanship of Mr. Leslie Scott, K.C., M.P., to consider defects in the existing system (1) of acquiring, and (2) of valuing, land for public purposes and to recommend any changes that may be desirable in the public interest. The Committee's first report deals with the general principles of acquiring land for public purposes. The valuation of land and special aspects of the question of acquisition—*e.g.*, in connection with mining, &c.—will be dealt with in subsequent reports.

The whole inquiry has an important bearing on post-war problems of Reconstruction, the essence of which lies in increasing national production to make good the wastage of war. To achieve this end the importance of a right handling of the question of land cannot be overstated. In certain aspects, land is obviously the immediate source of national wealth, as for example, in agriculture and coal and iron mining, with all their prospective developments, such as forestry, petroleum, and other mineral resources. Less obviously, perhaps, but no less actually, is the acquisition of land of vital necessity to almost every productive enterprise. The need for suitable sites, with adequate means of access and communication, water and power, almost inevitably binds down commercial undertakings in a thickly populated country like ours to the use of certain limited areas of land.

It is owing to this special position of land as a "necessary commodity of limited extent" that British law, in common with that of all highly civilised nations, recognises a special limitation of the rights of private ownership in land by authorising compulsory expropriation when public interest demands it, subject to just compensation for the owner. The Committee, therefore, address themselves in the first place to discussing the adequacy of existing means for giving effect to this admitted principle.

The result of their investigations is in some respects startling. Elementary education, for example, is one of the primary needs of the nation, and a normal school site does not involve the purchase of more than part of an acre. But the educational authority resorting to compulsory powers may be forced to incur an expenditure of some hundreds of pounds in costs, and a delay of several years, before obtaining possession of the required site. A special Parliamentary bill is necessary for every compulsory acquisition of land by the Office of Works (who are responsible for housing Government departments) and for every post-office site compulsorily acquired. Even for such requirements as Naval Defence and the provision of

light-houses Government departments have, in cases cited in the report, paid more in costs for the exercise of compulsory powers than the total value of the land acquired. Private promoters of commercial enterprise, no matter how desirable their schemes may be in the national interest, are even more unfortunately situated. The expenditure upon counsel, agents, and witnesses (who may have to appear again and again in the course of applications under the present Private Bill or Provisional Order procedure) renders compulsory acquisition of land virtually prohibitive for any private promoters save large corporations and the wealthiest companies. The ordinary man is left with the alternative of paying the landlord's price, should he consent to fix one, or abandoning his enterprise.

The Committee's unanimous conclusion is that some simpler, more uniform, and less costly procedure for compulsory acquisition of land has now become essential. Their chief concern is as to the kind of tribunal by which compulsory powers should be granted. They are opposed to any wholesale delegation of such jurisdiction from Parliament to Government Departments—who would thereby become the judges in cases in which they themselves were interested, directly or indirectly, one way or the other. The alternative of setting up a Standing Judicial Commission for this purpose is also rejected by the Committee—though most of them are legal men. They point out that such Commissions tend almost necessarily to become bound by their own precedents and stereotyped in their decisions; whereas the prime need of the new general machinery for the grant of compulsory powers is that it should be sufficiently elastic to adapt itself readily to the progressive needs and ideas of the nation at large.

The Committee's solution of the problem is directed to mending, rather than ending, the existing jurisdiction of the Parliamentary Committees for the investigation of schemes involving compulsory powers. The drawbacks to these tribunals are that their procedure is slow and costly, and that its extension to all proposals for the compulsory acquisition of land in future would make impossible demands on the time of Members of Parliament. On the other hand, the investigations of such schemes by Parliamentary Committees in the past have admittedly been marked (as the report emphasises) by a very high standard of justice and common sense, and their decisions, as being those of Parliament itself, have an element of authority and elasticity not attainable in the case of any purely extra-Parliamentary Tribunal.

The Land Acquisition Committee accordingly propose that a general Sanctioning Authority for the grant of compulsory powers in regard to land shall be set up in the form of a panel of Commissioners, including Members of Parliament and others of similar standing with general experience of affairs. Government officials or professional experts, as such, will not be included in the panel, but will have their proper opportunity of appearing as witnesses before the Tribunal. Any scheme involving the compulsory acquisition of land will be publicly (and so far as possible, locally) investigated by Commissioners chosen from this panel; and the decision of such Commissioners will be final on all questions of fact or the intrinsic merits of any scheme.

Full parliamentary control over matters of policy will be retained by providing for direct reference to Parliament upon any unsettled questions of principle; and all Members of the Panel (Parliamentary and non-Parliamentary) will be periodically appointed by a Parliamentary Selection Committee drawn from both Houses.

The Sanctioning Authority will thus become to all intents and purposes a sub-committee of Parliament, with co-opted Members from the large body of public-spirited men of all classes outside Parliament whose general experience fits them to act as Commissioners for such a purpose. Delays will be reduced by permitting schemes to be submitted to the Sanctioning Authority at any time of the year (instead of only during two months, as at present), and a final decision upon any scheme should normally be reached in a few weeks. Provision is made for reducing expenses by giving the Commissioners themselves a wide discretion over procedure and costs, with a direction to exercise their discretion in each case with a view to curtailing unnecessary evidence and discouraging unreasonable contention on either side.

The Committee in commending their report to the earnest consideration of the "powerful interests to whom some of their conclusions may seem hard of acceptance," point out that these conclusions involve no new principle and no element of confiscation. "Peace has been rudely shattered and its accumulations of wealth have been dissipated for a generation. The loss can only be repaired by the strictest possible economising of individual energy and the strongest possible stimulation of the nation's productive resources. The means necessary for production, and for the general well-being of the community (including the indispensable element of land) must be rendered accessible to industry and to responsible administrative authorities by a path direct and unencumbered. Avoidable complexities and unnecessary intermediaries must be eliminated."

GERMAN DYE INDUSTRY.

Boast to Undersell.

The attention of manufacturers in the chemical and dye industries ought to be drawn to recent issues of the German trade papers, wherein the present position of the dye industries in various countries is reviewed in the confident fashion characteristic of the Teuton.

In the first place, they assert that British, French, and Italian manufacturers will be obliged to offer their dyes at high prices, whereas they, with the State-fed companies, can sell at cost price, or even less. Moreover, the Germans are prepared to offer other products of chemical industry on the same terms, by which they hope to undersell all competitors. There is certainly danger that they will make good their boast, because their factories and works have been organised on this basis for a long time.

The person most interested in the dye-stuff problem is probably the textile manufacturer, and it is in this industry that the Germans hope to introduce the entering wedge by means of new dyes which they have made by what appear to be new methods. In the chemistry of dyes there is always the possibility that among the new products there may be some of especial value.

Costly Intermediates.—At first many textile manufacturers placed considerable confidence in optimistic reports in the newspapers, and were lulled into a sense of security in the belief that all dye-stuffs used in Entente industry would be manufactured in England and America by processes much in advance of the antiquated German methods. Some of these experiments have been tried, such, for instance, as the extraction of a red dye-stuff from the cranberry, the belief being apparently that vegetable colouring matters might in some cases take the place of synthetic dyes. The result of this and other expedients showed that in the present critical time it is a mistake to endeavour to prepare dye-stuffs by new and untried methods. The making of the finished and useful dyes is not, in the judgment of chemists, a difficult and complicated problem provided the proper so-called intermediate materials are available. The crux of the problem lies in the economical production of these intermediates, the by-products of the gas and coke-oven tars. But all these products are at very abnormal prices owing to the demand for high explosives. There is a disagreeable modicum of truth in the German contention that these prices must come down before the dye industry of the Allies can be organised on a good working basis.

Strength of German Industry.—Chemists do not deceive themselves as to the astonishing amount of strength in the German dye industry. After the war Germany will mainly rely upon dye-stuffs as articles of commerce destined to recover a place in the world's markets and to compensate her trade losses in other directions. The chief factor in this strength is the simple truth that German factories can turn out dyes and other chemicals cheaper than any other concerns. The cost of making these products in other countries, notably England, was clearly brought out in trade journals, which quote the preparations made by the different Governments to meet the expense. In England, for example, it seems necessary to feed the industry out of State money. The sum required, according to Sir Watson Rutherford, is £40,000,000. This is regarded by business men of all lines as a heavy capitalisation to produce the two and a quarter millions of dye-stuffs imported prior to the war.—"Manufacturer," in *Sunday Times*, Dec. 1, 1918.

SALE OF POISONS BY CORN MERCHANTS.

At a recent meeting of the Worcester City Council Mr. H. J. Aubrey, a local chemist, made a vigorous protest against the proposal of the Watch Committee to grant licenses under the Poisons and Pharmacy Act to a local firm of corn merchants for the sale of poisonous substances for use in agriculture or horticulture. He argued that the power to grant such licenses as given to Councils was only intended to be used in cases where there was difficulty in getting those compounds, but that could not be said to be the case in a city like Worcester where there were plenty of opportunities for such purchase. A rich firm like the applicants would not trouble to engage a solicitor to appear before the Watch Committee unless there was something behind it. During the war at any rate chemists would be precluded from dealing in corn, and why should corn merchants deal in poisons.

Mr. R. Haughton said that he was with Mr. Aubrey in protecting his profession, but he pointed out that other corn merchants were granted those licenses, and it would penalise this firm if they were not given one. He thought that Mr. Aubrey's remedy would be to move that on the expiration of the present licenses there should be no renewals.

Mr. Maund moved this, saying he thought it wrong that those poisons (some of which were very deadly) should be sold without the strictest supervision. There had been many cases of the misapplication of weed killers.

The Town Clerk said that there was a legal difficulty in adopting the course suggested by the amendment. Each case must be considered on its merits, though they might have previously made up their minds as to the merits. He suggested that the Committee should be asked to bring up a special report as to the renewal of the existing licenses.

The Mayor pointed out that what happened now was that an order sent to such a firm, if they had no license, was executed direct from the wholesalers, and that would happen in the future. Therefore the question of competition with the chemists did not arise.

Eventually it was decided to grant the license, and the Committee were asked specially to consider the question of the renewal of existing licenses.

The Detection of Organic Bases in By-products — Pyridine or other bases in coal-tar by-products when liquid may be detected as traces by shaking with magnesium bismuthate, a black reduction taking place.—J. C. Thomlinson, B.Sc.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, November 14, 1918.

Sir J. J. Thomson, O.M., President, in the Chair.

The following Papers were read, the Summary here printed having been supplied by the authors for use at the meeting:—

"*Sounds Produced by Drops Falling on Water.*" By A. Mallock, F.R.S.

"*Coefficients in the Expansion of Certain Modular Functions.*" By G. H. Hardy, F.R.S., and S. Ramanujan, F.R.S.

"*The Light Scattered by Gases: Its Polarisation and Intensity.*" By the Hon. R. J. Strutt, F.R.S.

"*An Investigation of the Ionising Power of the Positive Ions from a Glowing Tantalum Filament in Helium.*" By F. Horton, Sc.D., and Ann C. Davies.

The ionising power of the positive ions from a glowing tantalum filament in helium has been investigated by a modification of the method due to Lenard. The positive ions were accelerated through a piece of platinum gauze into the ionisation chamber, and were there retarded by an opposing potential difference between the gauze and a movable collecting electrode, this retarding potential being constant during a series of experiments and always greater than the greatest accelerating potential used in that series, so that none of the positive ions reached the collecting electrode.

It was found that an increasing current was obtained in the ionisation chamber (the electrode collecting a negative charge) when the potential difference accelerating the positive ions was gradually raised above 20 volts. This result is similar to that obtained by Pawlow, and by Bahr and Franck, who concluded that helium atoms are ionised by the collisions of positive ions moving with 20 volts velocity.

The experiments described in the paper have shown that the observed increasing current, with increasing accelerating potentials above, about 20 volts, is mainly due to the positive ions liberating electrons from the walls of the ionisation chamber which they bombard, and that the positive ions do not ionise the helium atoms even when they collide with velocities up to 200 volts.

THE ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS.

The following Memorandum has been addressed to the President of the Board of Trade—setting forth the views of the Executive Council of the above Association on the present situation in that section of Chemical Industry directly concerned with the production of Dyes.

The Council are of opinion—

1. That a wider and more comprehensive scheme of a completely National nature is immediately requisite, if a supply of the Colours, in variety and quantity essential to the conduct of our great Textile Industry, is to be forthcoming within a reasonable period of years, and especially with a view to the early elimination of all dependence on Overseas Supplies.

2. That the fundamental error which resulted in an inadequate policy in British Dye production is the failure on the part of the originators of that policy to recognise the fact that the manufacture of Dyes is not, by itself, an industry apart; but is precisely an integral part of, and is dependent upon, the operations covered by the Chemical Manufacturing Industry as a whole, *i.e.*, the

Manufacturer of Heavy Chemicals, of Fine Chemicals, of Tar Products, and of Explosives, have each and all separate functions to perform in developing a successful Dye Producing Industry in this country.

3. That the apparent failure to grasp the essential condition set forth in paragraph 2 has been the cause of the otherwise incomprehensible unwillingness on the part of the Governmental Officials concerned to consult this entirely representative Association of Chemical Manufacturers, and even to refuse the Conference offered by an Expert Committee of the Association, some months ago.

4. That the general trend of what Lord Moulton said at Manchester in December, 1914, is correct, when he pointed out that broadly speaking the manufacture of the greater proportion of essential Intermediates should be conducted at the existing Chemical Works of the country, leaving the actual production of the finished colours to be in some measure centralised.

5. That no such comprehensive scheme has yet been formulated, with the result that firms capable of adding useful weight to Dye Production have had insufficient opportunity for doing so, and that unless such opportunity is created, not only will time be lost, but unnecessary capital expenditure incurred in the erection of plant which already exists in whole or in part at the Chemical Works of the country.

6. That the past and present schemes have not included the whole of the country's resources of knowledge in actual colour production, and that, in short, there are potential dye makers who have not been used sufficiently, and whose powers of production have not been developed to the extent of which they are capable.

7. That the problem of distributing to the best advantage the large sums of money recently voted by Parliament for the development of the Dye Industry is one upon which this Association should advise. It is also felt that the *questions of priority for purchase of dye making* plant and the utilisation of materials are also matters in which the wide knowledge of this Association can be used effectively and it is urged that unless measures of co-operation of this nature are adopted the dangers of duplication of plant and of overlapping in processes will be seriously increased.

8. That unless co-ordinated action can be brought about to a much greater extent than is at present indicated the problem of meeting external or overseas competition in peace time will be more difficult and dangerous than is at present foreseen.

9. That the development of a British Organic Chemical Industry, capable of keeping abreast of Industrial achievements in the synthetic production of Dyes, Drugs, Explosives, Poisons, &c., is essential to the safety of the Empire. In this connection it is clear that the Dye Industry should be intimately co-ordinated with the other sections of Organic Chemical Industry if the success of the whole is to be secured.

10. To sum up, it is considered that—

(1) An *immediate co-operative effect* is called for and that a wider interest should be appealed to.

(2) The formation of those Companies on which Colour production will fall should not be confined in any sense.

(3) The whole Chemical Industry should be encouraged to assist, with both knowledge and money, an enterprise which is so vital to the maintenance and development of some of the country's most important industries.

As a consequence of this the directing or controlling body should be representative not only of Colour producing Interests and Colour Users, but also of those other and equally important factors in Chemical Manufacture, the good will and assistance of whom is of paramount importance in the National effort which has become essential.

November 1, 1918.

In reply to this the following letter has been received from the Dyes Commissioner:—

Dyes Department, Board of Trade,
7, Whitehall Gardens, S.W. 1.
November 8, 1918.

Dear Sir,—With reference to your letter of November 1 addressed to the President of the Board of Trade, which has been referred to me, enclosing a memorandum setting forth the views of your Association in connection with the development of the British Dye Industry, I have to inform you that full details of the scheme which H.M. Government propose to adopt for affording further assistance to the Dye Industry was presented to Parliament on the 6th instant, in the form of a White Paper, from which it will be observed that representation of your Association on the Trades and Licensing Committee which is to be set up under the scheme has been provided for.—I am, yours faithfully,

(Signed) Evan D. Jones,
Dyes Commissioner.

The General Manager, Association of
British Chemical Manufacturers.

From this it will be seen that only one of the points referred to in the Memorandum has been met, and that only to the extent of the appointment of one representative of this Association out of nine members of the Trades and Licensing Committee.

In view of the national importance of this matter my Association deems it necessary that the public should be informed of the position.—Yours faithfully,

G. Mount, Secretary.

NOTICES OF BOOKS.

The Zinc Industry. By Ernest A. Smith, Assoc.R.S.M. London, New York, Bombay, Calcutta, and Madras: Longmans, Green, and Co. 1918. Pp. viii+223. Price 10s. 6d. net.

The serious position of this country in regard to zinc supplies at the outbreak of war has found frequent mention and discussion in the Press, and the appearance of this monograph upon the zinc industry is most timely. It gives a general survey of the development of the industry and smelting, and other methods of zinc production are fully treated. The different types of furnaces used for smelting are accurately described and illustrated, and an attempt is made to estimate the cost of roasting per ton. The data can, however, of necessity not mean very much, as they refer mainly to pre-war conditions. The chapters on the physical and chemical properties of the metal are illustrated by good plates of micro-photographs. It is pointed out in the introduction that for many years 70 per cent of the zinc employed in this country was imported, although the Broken Hill deposits alone would be sufficient to supply the whole United Kingdom demand for metallic zinc, and it is much to be hoped that in the future the supplies of concentrates which used to be shipped to Germany for treatment will be dealt with in this country, and that there will be no possibility of the exploitation by Germans of the mineral resources of the British Empire.

Aids to the Analysis of Food and Drugs. By C. G. Moor, M.A. (Cantab), F.I.C., and William Partridge, F.I.C. Fourth Edition. London: Baillière, Tindall, and Cox. 1918. Pp. xii+268. Price, cloth, 4s. 6d. net; paper-cover, 4s. net.

In the latest edition of this useful book many alterations have been made, including the addition of fresh Regulations and Orders of Government Departments, and the description of methods of detecting new adulterants and preservatives which have come into use in recent times. New sections have been added on cider, hardened oils

the bleaching of flour, &c., and the practical analyst will find the book most convenient for reference and laboratory use. Many of the results of the authors' investigations are of considerable value in food analysis, and the descriptions of the methods they have adopted and the conclusions arrived at will frequently be found useful by less experienced workers. Notes on the British Pharmacopœia are included, and an appendix gives details of alteration in composition of food and drugs due to the war.

The Chemists' Pocket Annual. By RICHARD K. MEADE, M.S. Third Edition. Easton, Pa.; The Chemical Publishing Co. London: Williams and Norgate. Tokyo: Maruzen Co., Ltd, 1918. Pp. v+530. Price 3.50 dols.

THE third edition of this manual has been very considerably enlarged, and many additions have been made to it, so that it is now about three times as large as the original issue in 1900. A specially notable increase is that in the sections relating to chemical engineering, data and tables of statistics of fuels, combustion, &c., being much more copious than before. The analytical sections have also undergone revision, and methods for determining various metals in their ores have, for example, been added. The analysis of alloys, the testing of lubricating oils, &c., are now treated fully, and good bibliographies are given. Nothing but continual use would perhaps enable one to vouch for the accuracy of the data and tables, but to judge by the earlier editions the most critical could not justifiably find fault with the book in this respect, and it is certainly comprehensive in its scope, and the information given is clear and conveniently arranged.

I Fenomeni Elettro-atomici sotto l'Azione del Magnetismo. ("Electro-atomic Phenomena under the Action of Magnetism"). By AUGUSTO RIGHI. Bologna: Nicola Zanichelli. Pp. xvi+435. Price 21 francs.

THIS volume contains a comprehensive account of the author's experimental work, and the hypotheses he has based upon it, expressed in language which the educated reader should be able to follow, even though he possesses no detailed knowledge of physics. These experiments have extended over more than forty years, having given Prof. Righi an undisputed right to a place in the front rank of modern scientific men, and this exposition of his work will be warmly welcomed. A short introductory chapter, which the scientific reader may, if he likes, omit, gives a *résumé* of modern views on the theory of ionisation, the nature of electrons, &c. Then the subject upon which the author has done so much valuable work—the influence of magnetism on the production of the electric discharge is discussed, and the theory of magneto-ionisation is put forward. It is shown how this theory satisfactorily explains the observed facts, and the author claims that it has been amply confirmed. The descriptions of the observations of ionomagnetic rotations in Chapter IV. are particularly interesting, and finally the influence of magnetic fields upon electric currents in metals and liquids is treated in the last chapter. The appendices contain short expositions of the application of mathematics to the subject, and the working out of calculations for the benefit of those readers who wish to go more thoroughly into it.

Royal Institution.—At a General Meeting of the Members on Monday, December 2, Sir James Crichton-Browne, Treasurer and Vice-President in the Chair, the following gentlemen were elected Members:—Viscount Knutsford, H. Bradford, L. F. Everest, and John C. S. Rashleigh. Thanks of the Members were returned to Mrs. Edward Pollock for the present of portraits of the late Dr. and Mrs. Warren de la Rue, and to Dr. Dundas Grant for the donation of £25 5s. to the Research Fund.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

NOTE.—All degrees of temperature are Centigrade unless otherwise expressed.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxvii., No. 7, August 12, 1918.

This number contains no chemical matter.

No. 8, August 19, 1918; No. 9, August 26, 1918.

These numbers contain no chemical matter.

No. 10, September 2, 1918.

Determination of Nitrites.—F. Dienert.—Nitrites can readily be estimated by Kalmann's method:—$NaNO_2+2HI=NaI+I+NO+H_2O$, if due precautions are taken to exclude oxygen. The estimation then depends only upon the determination of iodine. A current of carbon dioxide is first passed through a flask containing 2 grms. of potassium iodide in 50 cc. of water, then through a second flask containing 10 cc. of normal sulphuric acid, and then into a third flask containing the nitrite to be estimated. The current of gas is allowed to pass for a quarter of an hour, and then the contents of the first flask are poured into the second, and the mixture of iodide and sulphuric acid is finally poured into the third flask. The yellow coloration due to the liberation of iodine at once appears. Then 10 cc. of a 20 per cent solution of ammonium carbonate are run in, and the iodine can then be titrated with N/70 arsenious acid in presence of air. The method gives very accurate results if all precautions are taken to prevent the introduction of oxygen before the alkaline solution is added.

No. 11, September 9, 1918.

This number contains no chemical matter.

No. 12, September 16, 1918.

Partial Sterilisation of Soils.—G. Truffaut.—The author has carried out some large scale experiments to investigate the partial sterilisation of soils by means of carbon di-sulphide, calcium sulphide, and aromatic hydrocarbons. The conclusions of Russell and Miège are confirmed by his results. Considerable increases in the yields of crops were observed, and the development of animal and vegetable parasites appeared to be prevented.

MISCELLANEOUS.

Alcohol and Glycerin.—The Ministry of Munitions notify that there are now supplies of alcohol available for industrial purposes, and that manufacturers should be able to obtain their requirements from their usual suppliers without restriction, subject of course to the usual reglations of the Board of Customs and Excise. Methylated spirit is again available to the public. Glycerin should, in a few days, be purchasable in the ordinary way from chemists, stores, &c. Arrangements have been made which enable glycerin producers to supply substantial quantities for general use.

Christmas Deliveries by Motor.—The President of the Board of Trade having considered the representations of the Commercial Motor Users Association, the Petrol Controller has arranged forthwith "to consider on its merits any individual application for an increased allotment, in view of the additional quantity of food-stuffs to be delivered during December." Captain F. G. Bristow, the General Secretary of the Association, 83, Pall Mall, S.W. 1, will be glad to assist traders using commercial motors for the distribution of food-stuffs who desire to make special claims.

British Science and Invention Exhibition.—In view of the wide public interest taken in the British Scientific Products Exhibition, held at King's College, London, during the past summer, the British Science Guild has decided to organise another Exhibition next year. The main object of the Exhibition will be to stimulate national enterprise by a display of the year's progress in British science, invention, and industry. Further particulars of the Exhibition will be available in due course. A large part of the recent Exhibition has been transferred to Manchester, where it will be on view at the Municipal College of Technology towards the end of December.

Petrol and Paraffin Prices.—Following upon the reception of two deputations from the Standing Joint Committee of Mechanical Road Transport Associations, Capt. F. G. Bristow, the Hon. Secretary, has been officially notified that there will be 2d. per gallon reduction in the prices of petrol and paraffin as from next Monday. The deputations were received by Sir John Cadman, K.C.M.G., Director of H.M. Petroleum Executive, and Sir Walter Egerton, K.C.M.G., Chairman of the Petroleum Supplies Pool Board. The deputations included delegates from Commercial Motor Users Association, Furniture Warehousemen and Removers Association, London and Provincial Omnibus Owners Association, National Motor Cyclists Fuel Union, National Traction Engine Owners and Users Association, Royal Agricultural Society of England, Showmen's Guild, Steam Cultivation Development Association.

NOTES AND QUERIES.

New Industries.—Mr. JAMES CREEDE, care of Campbell, 107, Clackston Road, Cathcart, Glasgow, desires to have information *re* Fixation of Atmospheric Nitrogen (Elmore's Patent), as he is anxious to get into touch with someone interested in the erection of works for same.——Mr. PAUL VILLIAN, Warwick Lodge, 14, Effra Road, Brixton, S.W. 2, and Mr. H. S. MORRAN, "Treganna," King's Road, Fleet, Hants, both require information on manufacture of Soaps.——Mr. T. H. GIBBARD, 33, Poplar Grove, New Malden, Surrey, requires particulars with regard to research work connected with the production of Casein—Glue Compounds.——Mr. TREVOR TREGASKIS, 85, Finnart Street, Greenock, N.B., desires information *re* the manufacture of Plaster of Paris, in which gypsum is the raw material required.——Capt. T. L. COPPOCK, Mayfield, Whitchurch, Cardiff, desires technical information on Refining Mineral Oils and making Lubricating Grease and Disinfectants, after peace.

TO comply with Regulation 8 (*b*) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

Chemist (46) desires Appointment, with Partnership or Financial Interest, with Agricultural or Analytical Chemist or Dairy Company.—Address, "C. 46," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist, B.Sc., London (Hons. in Chemistry), seeks Research appointment with large manufacturing firm.—Address, G. L., CHEMICAL NEWS Office 16, Newcastle Street, Farringdon Street, London. E.C. 4.

Chemist (Hons. B.Sc. Chemistry), with Technical Analytical and Research experience, requires Post.—Address, S., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Youth, 19 (Lond. Matric.), requires Situation as Junior in Works Laboratory. Some experience in Public Analyst's Laboratory.—Address, "Peace," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, fully trained, qualified, and experienced Organic Chemist to take charge of Research Laboratory.—Apply, with full particulars of qualifications and experience, to "F. 396," 34, Union Street, Birmingham.

Works Analytical Chemist required. One conversant with Soap Manufacture, Nicotine Extractions, and Agricultural and Horticultural Preparations. State full particulars and salary required.—Address, W. A., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, Assistant Chemist with experience in the analysis of Iron, Steel, and Non-ferrous Alloys, for large Works in the North of England. No one at present engaged on Government work need apply.—Write, stating age, experience, and wages required to nearest Employment Exchange, quoting No. A 6182.

WANTED TO PURCHASE.

A copy of Latest Edition of "URE'S DICTIONARY OF CHEMISTRY."—Address, "Ure," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street London, E.C. 4.

ROYAL SOCIETY.

GOVERNMENT GRANT for SCIENTIFIC INVESTIGATIONS.—Applications for the year 1919 must be received at the Offices of the Royal Society not later than JANUARY 1 next, and must be made on printed forms to be obtained from the Clerk to the Government Grant Committee, Royal Society, Burlington House, London, W. 1.

STAFFORDSHIRE EDUCATION COMMITTEE

An ASSISTANT MASTER or MISTRESS, qualified to teach Elementary Mathematics and Science, is required for Secondary School work.

Commencing salary up to £250 (man) or £200 (woman), non-resident.

Further particulars and forms of application may be obtained from the undersigned.

C. F. MOTT,
County Education Offices, Acting Director of Higher Education.
Stafford, November, 1918.

UNIVERSITY OF MANCHESTER
(*Faculty of Technology*)

Manchester Municipal
COLLEGE OF TECHNOLOGY

APPOINTMENT OF PROFESSOR OF TEXTILE TECHNOLOGY

Applications for the Professorship of Textile Technology in the Faculty of Technology of the University of Manchester invited by the City Council and the University jointly, may be received until 15th January, 1919, the date having been deferred in the interests of possible candidates who have been serving with H.M. Forces.

Salary, £800 a year.

Conditions of appointment and form of application may be obtained from the Registrar, College of Technology, Manchester.

Canvassing, either directly or indirectly, will disqualify a candidate for appointment.

APPOINTMENTS REGISTER.

A Register of FELLOWS and ASSOCIATES of the INSTITUTE OF CHEMISTRY who are available for Appointments is kept at the Offices of the Institute. Applications for the services of Chemists should be forwarded to THE REGISTRAR, The Institute of Chemistry, 30, Russell Square, London, W.C. 1.

COMPETITIVE ESSAYS on "EXPLOSIVES."

The DORSET FIELD CLUB announce that the CECIL MEDAL and PRIZE of £10 will be awarded in May, 1919, for the best paper on "Explosives used in Warfare from the time of the Crusades to the present War, giving details (unobjectionable from a military point of view) of each invention, and the chemical proportions of the substances used in each case, commencing with gunpowder and Greek fire." Open to any person between the ages of 17 and 35 on May 1, 1919, either born in Dorset or resident not less than one year between May 1, 1917, and May 1, 1919.

Particulars from MR. H. POUNCY, Midland Bank Chambers Dorchester.

ORDER THE PAPER.

In consequence of the "No Returns Order" of the Government, readers of the "Chemical News" are requested to ensure a regular supply of the paper by placing an order with their Newsagent.

THE CHEMICAL NEWS.

VOL. CXVII., No. 3063.

SPECIAL NOTICE TO SUBSCRIBERS.

THE recent paper restrictions have compelled us to publish only fortnightly instead of weekly for a time, but we are now glad to be able to announce that we are to be allowed a further supply of paper, which will enable us to revert to weekly publication in the near future.

Beginning with No. 3064, to be published on January 1, 1919, the CHEMICAL NEWS will again appear weekly, and the dates of expiration of subscriptions will be adjusted accordingly.

Individual notices will be posted to subscribers, or their agents, on the expiration of their subscription periods. The price will remain unaltered, viz., £1 for fifty-two numbers, or *pro rata*.

CRITICAL PHENOMENA.

By WILLIAM R. FIELDING, M.A., M.Sc.

ABOUT two years ago the author attempted to obtain a general formula connecting the critical temperature of a gas and its critical pressure, and although he met with a certain measure of success the exigencies of the present times necessitated that he should put the problem on one side until a more convenient season. But in the CHEMICAL NEWS (1918, cxvii., 228) the very question was referred to, E. Ariès applying a formula he had obtained for the argon elements to obtain the critical data of the monatomic gas mercury.

As I have calculated the critical data of most of the elements and several compounds, I have decided to place my conclusions before the readers of the chemical world. The present paper was originally based on results not yet published, in which the author proved that for inorganic elements and compounds the

$$C.T. = (1{\cdot}714 \times B.P.) + 3{\cdot}3^{\circ}$$

(all temperature readings being on the absolute scale).

At comparatively low temperatures this formula is not quite correct, but as the temperature rises it becomes more generally correct (Table I.).

TABLE I.

	C.T.	B.P.	C.T./B.T.
H	38·5	20·5	1·88
F..	? 118	? 86	1·37
N	127	77·3	1·64
O..	154	90·5	1·7
A..	155·6	87	1·79
Kr	210 5	121·3	1·73
X..	287·8	164	1·75
NH_3	404	239 6	1·69
Cl	414	239·4	1·72
H_2O	643	373	1·72

These examples are given so as to justify the assumption, based on evidence which cannot now be given, that the critical temperature of a substance is obtained by multiplying its boiling-point on the absolute scale by 1·71. For carbon the critical temperature is about 6500 on the absolute scale, equal to, or slightly higher than, the temperature of the sun itself.

The next question to be settled is, "What is the relation between the temperature and the pressure at the critical temperature?" If we plot critical temperatures against critical pressures we shall find that all substances do not lie on one curve; but the argon elements appear to lie on one curve; hydrogen, fluorine, chlorine, &c., on another. In fact, there appears to be a separate curve for each group of elements or similarly constituted compounds.

The Halogen Compounds.

After frequent trial I found that $\frac{C.T. - x}{\sqrt{C.P.}}$ was constant for this group; *i.e.*,—

$$\frac{\text{C.T. of hydrogen} - x}{\sqrt{\text{C.P. of hydrogen}}} = \frac{\text{C.T. of chlorine} - x}{\sqrt{\text{C.P. of chlorine}}}$$

TABLE II.

Data.		H.	F.	Cl.	Br.	I.
C.T.	..	38·5	118	414	569	783
					(calc. from boiling points)	
C.P.	..	15	25	84	?	?

$$\therefore \frac{38{\cdot}5 - x}{\sqrt{15}} = \frac{414 - x}{\sqrt{84}}$$

$$\therefore x = -236{\cdot}2.$$

The critical pressures of fluorine, bromine, and iodine can now be calculated from—

$$\frac{38{\cdot}5+236{\cdot}2}{\sqrt{15}} = \frac{118+236{\cdot}2}{\sqrt{\text{C.P. of fluorine}}}$$

$$= \frac{569+236{\cdot}2}{\sqrt{\text{C.P. of bromine}}}$$

$$= \frac{783+236{\cdot}2}{\sqrt{\text{C.P. of iodine}}}$$

and prove to be 24·9 (observed C.P. 25 atmos.), 128·9, and 206·4 atmos. respectively. The results are given in Table III.

TABLE III.

	C.T.	C.T.+236·2.	C.P.	√C.P.	$\frac{C.T.+236{\cdot}2}{\sqrt{C.P.}}$
H ..	38·5	274 7	15	3 872	70·92
F ..	118	354·2	25	5	70·84
Cl ..	414	650·2	84	9·165	70·94
Br ..	569	805·2	128 9	11·35	70·94
I ..	783	1019·2	206·4	14·36	70·97
Mn..	3694	3930·2	3072	55·5	70·9
Also—					
X ..	287·8	524	57·2	7·563	70 (nearly)
N ..	124	360·2	27	5·2	70 (nearly)

If critical data respecting two elements in any group is known, the critical temperature and pressure of every other element in that group can readily be calculated. Excepting the argon group, in no other group is this data available. Nitrogen and oxygen are the only elements in their respective groups whose critical temperatures and pressures have been observed; further, there is no available data respecting any metallic element. Another difficulty is the conflicting data; *e.g.*, the critical pressure of nitrogen is given as 27 and 35 atmospheres. Can we obtain any information from the compounds of substances whose critical data we wish to calculate? Take, first, the compounds of the halogen elements (including hydrogen) with each other (Table IV.).

TABLE IV.

	HH.	HF.	HCl.	HBr.	HI.
B.P.	20·5 (obs.)	293·4 (obs.)	189·3 (obs.)	200 (obs.)	239 (obs.)
C.T.	38·5 (obs.)	498·8 (calc.)	325 (obs.)	340 (calc.)	406 (calc.)
C.P.	15 (obs.)	?	93 (obs.)	?	?

TABLE VII.

	C.T.	C.P.	R.	C.P.	R.	C.P.	R.
H_2S	373	92 (obs.)	0·8	100 (obs.)	0·74	100 (obs.)	0·74
H_2Se	410	104 (calc.)	0·8	111·3 (calc.)	0·746	112 (calc.)	0·74
H_2Te	464	122·7 (calc.)	0·8	128·6 (calc.)	0·76	130·5 (calc.)	0·747
H_2O	643	196 (obs.)	0·78	196 (obs.)	0·78		
H_2O	638					200·5 (obs.)	0·76
H_2S	373	94·6 (calc.)	0·78	90 (obs.)	0·82	94·5 (calc.)	0·781
H_2Se	410	106·3 (calc.)	0·78	106 (calc.)	0·78	107 (calc.)	0·776
H_2Te	464	124·7 (calc.)	0·78	125·4 (calc.)	0·78	126 (calc.)	0·774
H_2O	643	196 (obs.)	0·78	196 (obs.)	0·78	201·5 (calc.)	0·763

Then—

$$\frac{38·5-x}{\sqrt{15}} = \frac{325-x}{\sqrt{93}}$$

$$X = -153·6$$

$$\frac{38·5+153·6}{\sqrt{15}} = \frac{\text{C.T. of substance}+153·6}{\sqrt{\text{C.P. of substance}}}$$

Therefore, the C.P. of HF, HBr, HI are probably 173·4, 99, 128·8 atmos. respectively. (These values will be slightly readjusted later). How does the observed C.P. of HCl compare with the C.P. calculated from hydrogen and chlorine; *i.e.*, from the formula—

$$\frac{\text{C.T.}+236·2}{\sqrt{\text{C.P.}}} = 70·9) ?$$

	H.	HCl.	Cl.
C.T.	38·5	325	414
C.P.	15	93	84

$$\therefore \frac{38·5-X}{\sqrt{15}} = \frac{414-X}{\sqrt{84}}$$

$$\therefore X = -236·2.$$

Therefore $\frac{\text{C.T.}+236·2}{\sqrt{\text{C.P.}}} = 70·9$ for H, HCl, and Cl.

$\therefore$ C.P. of HCl = 62·7 atmos,
= ⅔ of the observed result.

We have already calculated the C.P. of HBr to be 99 atmos.; but if we calculate it from the critical data of H and Br it is 66 atmos.; *i.e.*, ⅔ of the correct value.

This is, for HCl, HBr, HF, and HI, the ratio of—

$$\frac{\text{C.P. (calculated from the constituents)}}{\text{C.P.}} = ⅔ \text{ nearly.}$$

In future we will refer to this ratio as R. The fact that a similar relationship exists all through a group of similar compounds is helpful in confirming the C.P. of the constituent elements.

N, P, As, Sb, Bi.

The following data is available:—

	N.	P.	As.	Sb.	Bi.
C.T.	124	959 (calc.)	1076 (calc.)	3184 (calc).	2904 (calc.)
C.P.	27	?	?	?	?

If the critical pressure of phosphorus had been known we could easily have calculated the critical pressures of arsenic, antimony, and bismuth. I have arranged the critical data of the elements (as far as known) in Table V.

TABLE V.

	C.T.	C.P.
H	38·5	15
F	118	25
N	124	27
O	154	50·8, 58
A	155·6	52·9
Kr	210·5	54·2
X	287·8	57·2
Cl	414	84
Br	569	129
I	783	206
P	959	?
As	1076	?

It will be noticed that the critical pressure rises as the critical temperature.

We have already seen that for nitrogen—

$$\frac{124+236·2}{\sqrt{27}} = 70 \text{ neatly.}$$

By slightly adjusting the C.T. or C.P., or both nitrogen would behave as if it were in the halogen family and would support the view that—

$$\frac{\text{C.T.}+236·2}{\sqrt{\text{C.P.}}} = 70·9$$

applies to *all* elements, whatever the group. For example the observed critical temperature of nitrogen is 124 and 127. If it had been 130 the calculated critical pressure would have been 26·63 (observed C.P. 27 atmos.). If it had been 132·2 the calculated C.P. would have been exactly equal to the observed. Further, the ratio of the C.T. to the B.P. would then be 1·71 (instead of 1·64 as at present).

The critical pressures of phosphorus, arsenic, antimony and bismuth were now calculated from what we shall regard as a general formula, and proved to be 284, 342, 2327, 1960 atmos. respectively.

To confirm these results I calculated R for their hydrides.

The Hydrides of N, P, As, Sb.

	NH_3.	PH_3.	AsH_3.	SbH_3.
C.T.... ..	404	320	396 (calc.)	435 (calc.)
C.P... ..	113	64	?	?

Then—

$$\frac{404-X}{\sqrt{113}} = \frac{320-X}{\sqrt{64}}$$

$$\therefore X = 64·5.$$

Therefore—

$$\frac{404-64·5}{\sqrt{113}} = 31·9.$$

The critical pressure of AsH_3 = $\frac{396-64 \cdot 5}{\sqrt{C.P.}}$ = 31·9

$\therefore \sqrt{C.P.}$ = 10·4

$\therefore$ C.P. = 108

The critical pressure of SbH_3 = $\frac{435-64 \cdot 5}{\sqrt{C.P.}}$ = 31·9

$\therefore \sqrt{C.P.}$ = 11·61

$\therefore$ C.P. = 135

The critical pressure, of NH_3, PH_3, AsH_3, SbH_3 were next calculated from their elements; *i.e.*, from the general formula, and proved to be 81·5, 61·5, 79·5, 89·6 atmos. respectively. The results are given in Table VI.

TABLE VI.

	C.T.	C.P.	C.P. (from elements)	R
PH_3	320	64	61·5	0·96
AsH_3 . ..	396	108	79·5	0·73
NH_3	404	113	81·5	0·72
SbH_3 . ..	435	135	89·6	0·66

In this group of hydrides the value of R decreases with a rise in the critical temperature.

Oxygen, Sulphur, Selenium, Tellurium.

	O.	S.	Se.	Te.
C.T...	154	1220 (calc.)	1637 (calc.)	2827 (calc.)
C.P...	51, 58	?	?	?

From the curve and from the general formula the critical pressure of oxygen, corresponding to a C.T. of 154, should be 30·25 atmos.

$$\frac{154+236 \cdot 2}{\sqrt{C.P.}} = 70 \cdot 9$$

$$\therefore C.P. = 30 \cdot 25$$

Why this is so different from the observed result I cannot say; but it is rather remarkable that the observed C.P. of oxygen (51) is the C.P. corresponding to 262, which is the critical temperature of ozone. This is probably merely a coincidence, for in the argon group xenon is the only element which fits in with the general scheme.

From the formula, the C.P. of sulphur, selenium, and tellurium are 422, 698, 1866 atmos. respectively.

Each element forms a compound with hydrogen; but unfortunately the critical data respecting these hydrides is very unreliable; *e.g.*, the C.P. of H_2S is 90, 92, and 100 atmos!

Calculating from their elements, the C.P. of H_2S, H_2Se, H_2Te, H_2O are 73·83, 83·06, 97·5, and 153·75 atmos. respectively.

What are the probable C.P. of these compounds?

	H_2S.	H_2Se.	H_2Te.	H_2O.
C.T. ..	373	410	464 (calc.)	643, 638
C.P. ..	90, 92, 100	91 ?	?	196, 200·5

From the relationship—

$$\frac{\text{C.T. of } H_2S - X}{\sqrt{\text{C.P. of } H_2S}} = \frac{\text{C.T. of } H_2O - X}{\sqrt{\text{C.P. of } H_2O}}$$

I found X for the series and then the critical pressures of H_2Se and H_2Te. If the C.P. of H_2S and H_2O are 92 and 196 respectively, X = −214, and C.P. of H_2Se and H_2Te are 104 and 122·7 atmos. respectively. If C.P. of H_2S and H_2O are 100 and 200·5 respectively, X = −267 and the C.P. of H_2Se and H_2Te and 112 and 130·5 respectively. The results are given in Table VII.

When the critical pressures of H_2S and H_2O are 94·5 and 201·5 atmos. respectively, X for the series is −214.

The Hydrides of Carbon and Silicon.

The critical temperature of silicon tetra-hydride is stated to be about 0° C. (Ogier, *Comptes Rendus*, 1879, lxxxviii., 236), and as a pressure of 100 atmos. is required to condense the gas at −1° C., 70 atmos. at −7° C., and of 50 atmos. at −11° C. the C.P. of SiH_4 will evidently be about 105 atmos.

	CH_4.	SiH_4.
C.T.	199	273
C.P.	57	105

From—

$$\frac{199-X}{\sqrt{57}} = \frac{273-X}{\sqrt{105}}$$

$$X = -8.$$

The Value of X in the Series of Hydrides.

Halogen family	−153·6	
Oxygen ,, ...		−214
Nitrogen ,, ...	+64·5	
Carbon ,, ...		−8
Difference	218·1	206

As there is no critical data respecting, say, the chlorides of these elements, it is impossible to say whether the difference in the values of X in alternate groups should be coincident or not. Probably the only value of X in dispute is that for the halogen acids, derived from HH (not an acid) and HCl. If X in this series proved to be −141·5 then the difference in the value of X in alternate groups would be the same (*i.e.*, 206). This change in the value of X would necessitate a slight readjustment in the critical pressures of the halogen acids, for now—

$$\frac{\text{C.T. of HCl}+141 \cdot 5}{\sqrt{93}} = \frac{\text{C.T. of HI}+141 \cdot 5}{\sqrt{\text{C.P. of HI}}}$$

The C.P. of HCl, HBr, HI, HF will be 93, 99, 128, 175; and R will be 0·674, 0·66, 0·64, 0·61 respectively.

Table VIII. epitomises the results we have obtained so far.

TABLE VIII.

H.		C.T. 38·5.	C.P. 15.	Halogen family. R.	Oxygen family. R	Nitrogen family. R.	Carbon family. R.
CH_4	..	199	57	—	—	—	0·66
SiH_4	..	273	105	—	—	—	0·52
PH_3	..	320	64	—	—	0·96	—
HCl	..	325	93	0·674	—	—	—
HBr	..	340	99	0·66	—	—	—
H_2S	..	373	94·5	—	0·781	—	—
AsH_3	..	396	108	—	—	0·73	—
NH_3	..	404	113	—	—	0·72	—
HI..	..	406	128	0·64	—	—	—
H_2Se	..	410	107	—	0·776	—	—
SbH_3	..	435	135	—	—	0·66	—
H_2Te	..	464	126	—	0·774	—	—
HF .	..	499	175	0·61	—	—	—
H_2O	..	638	201·5	—	0·763	—	—

The critical data of the chief elements (Table IX.) is calculated from—

$$\frac{C.T. + 236 \cdot 2}{\sqrt{C.P.}} = 70 \cdot 9.$$

(E. Ariès calculated the C.T. of mercury vapour to be 1077° C. and the C.P. 420 atmos.).

Critical Data of Organic Compounds.

Data respecting several series of organic compounds is available, and in every case the critical pressure decreases as the critical temperature increases. Only occasionally does—

$$\frac{C.T. - X}{\sqrt{C.P.}} = k$$

give satisfactory results; more often the product C.T. × $\sqrt{C.P.}$ gives closer agreements.

TABLE IX.

	B.P.	C.T.	C.P.
H	20·5	38·5	15
F	86	118	25
N	77·3	130	26·63
		124	27·5
O	90·5	154	51 (30·25)
A	86·9	155·6	52·9
Kr ..	121·3	210·5	54·2
X	163·9	287·8	57·2
Cl . ..	239·4	414	84
Br ..	332	569	129
I	457	783	206
P	563	959	284
Hg ..	630	1071	340
As . ..	633	1076	342
S	718	1220	422
Cs ..	943	1603	676
Se ..	963	1637	698
Rb ..	969	1647	705
K . ..	1030·5	1752	786
Cd ..	1051	1787	814
Na ..	1150·5	1956	935
Zn ..	1191	2025	1017
Mg ..	1393	2368	1349
Be ..	1500	2550	1544
Tl . ..	1553	2640	1645
Te ..	1663	2827	1866
Li . ..	1673	2844	1887
Bi . ..	1708	2904	1960
Pb ..	1798	3057	2158
Sb ..	1873	3184	2327
Al . ..	2073	3524	2812
Mn ..	2160	3694	3072
Ag ..	2228	3788	3220
Sn ..	2543	4323	4134
Cu ..	2583	4391	4260
Fe ..	2707	4629	4708
C	3773	6500	9025

I. *Hydrocarbons of the Methane Series.*

	C.T.	C.P.	$\sqrt{C.P.}$	C.T. × $\sqrt{C.P.}$
CH_4	199	57	7·55	1502·45
C_2H_6	310	45	6·70	2077
C_5H_{12}	460·5	33·3	5·77	2657
C_6H_{14}	507·5	30	5·48	2781
C_8H_{18}	569·4	25·2	5·02	2858·4
$C_{10}H_{22}$	603·4	21·3	4·61	2781·7

(Note how the product tends to become constant when C_4H_{10} has been passed, *i.e.*, when the possibility of isomerism has been passed).

II. *The Alkyl Chlorides and Nitriles.*

HCl	325	93	9·643	3134
CH_3Cl	415	76	8·72	3618·8
C_2H_5Cl	456	54	7·35	3351·6
C_3H_7Cl	494	49	7	3458
CH_3CN	543	47·7	6·907	3750·5
C_2H_5CN	558·7	41·3	6·426	3590·2
C_3H_7CN	582	37·4	6·116	3559·5
C_5H_9CN	621·8	32·1	5·665	3522·5

(Note the "jump" caused by the introduction of the first methyl group).

III. *Sulphides.*

H_2S	373	100	10	3730
$(CH_3)_2S$	504·3	56·14	7·49	3777·2
$(CH_3)(C_2H_5)S$ ..	533·6	41·9	6·47	3446·3
$(C_2H_5)_2S$	[illegible]·6	47·1	6·[illegible]	3825
$(C_2H_5)HS$	501·3	63·5	7·97	3995·4

IV. *Homologues of Benzene and other Hydrocarbons.*

	C.T.	C.P.	$\sqrt{C.P.}$	C.T. × $\sqrt{C.P.}$
C_6H_6	554	50·1	7·08	3922
$C_6H_5\,CH_3$	593·6	41·6	6·45	3828·7
$C_6H_5.C_2H_5$	619·4	38·1	6·17	3821·7
$C_6H_4(CH_3)_2$, *o*-xylene	631·3	36·9	6·075	3835·1
$C_6H_3(CH_3)_3$ 1.3.5-mesitylene ..	643·5	33·2	5·762	3687·8
$C_6H_3(CH_3)_3$, 1.2.4-pseudo-cumene .	654·2	33·2	5·762	3769·5
V.				
o-Xylene	631·3	36·9	6·075	3835·1
m-Xylene	618·6	35·8	5·983	3701·1
p-Xylene	617·4	35	5·916	3652·5
VI.				
Methyl benzene ..	593·6	41·6	6·45	3828·7
Ethyl benzene ..	619·4	38·1	6·17	3821·7
Propyl benzene ..	638·6	32·3	5·683	3629
Isopropyl benzene	635·6	32·2	5·674	3606·4
Butyl benzene ..	? 653	? 31·2	? 5·585	? 3647
Isobutyl benzene ..	650·1	31·1	5·58	3627·6
VII.				
Methane	199	57	7·55	1502·5
Phenyl methane ..	593·6	41·6	6·45	3828·7
Diphenyl methane	770	28·2	5·31	4088·7
VIII.				
Phenyl methane ..	593·6	41·6	6·45	3828·7
Phenyl ethane ..	619·4	38·1	6·17	3821·7
Phenyl propane ..	638·6	32·3	5·683	3629
Phenyl butane ..	? 653	? 31·2	? 5·585	? 3647
IX.				
Benzene	554	50·1	7·08	3922
Diphenyl	768·6	31·8	5·64	4334·9
Naphthalene ..	741·2	39·2	6·26	4639·9

X. *Comparison of the First Member of Different Series of Hydrocarbons.*

(Arranged in order of increasing unsaturation).

Methane	199	57	7·55	1502·5
Ethylene	283	58	7·62	2156·5
Acetylene	310	68	8·25	2557·5
Benzene	554	50·1	7·08	3922

Conclusions.

1. The formula $\frac{C.T. + 236{\cdot}2}{\sqrt{C.P.}} = 70{\cdot}9$ applies to the elements and a similar formula $\frac{C.T. - X}{C.P.} = k$, where X and k depend on the series to which the substance belongs, applies to inorganic compounds. E. Ariès has calculated the critical data of mercury vapour from the behaviour of krypton, argon, and xenon, the two first of which, like oxygen and helium, behave in an irregular manner and do not lie on the critical curve.

2. The C.T. and C.P. of compounds are not the sums of the C.T. and the C.P. of their constituents; but in inorganic compounds, as the C.T. rises the C.P. rises, and the value of R falls (in any particular series of similar compounds); whereas in organic compounds as the C.T. rises the C.P. falls, and the value of R rises (in any particular series of similar compounds).

3. In the case of benzene derivatives the value C.T. × $\sqrt{C.P.}$ is highest for the ortho-position and lowest for the para-position. (Compare the xylene, Series V.).

4. The value of C.T. × $\sqrt{C.P.}$ is slightly higher for the normal than for the iso-position. (Compare Series VI.).

5. As the number of benzene rings in a compound increases so does the value of C.T. × $\sqrt{C.P.}$ (Compare Series IX.).

6. The substitution of one phenyl radical for H in a methane molecule raises the value of C.T. × √C.P.; the introduction of a second phenyl radical raises the product of C.T. × √C.P. still further. (Series VII.).

7. The introduction of one methyl radical into the benzene ring reduces the value of C.T. × √C.P.; a second methyl (in the ortho-position) causes no further change; a third methyl radical probably causes no further change (if the methyl radicals are in the 1.2.3-positions).

Compare the Tri-methyl Benzenes.

1.2.3-Hemi-mellitene	?	?	?	? 3840
1.2.4-Pseudo-cumene	654·2	33·2	5·762	3769·5
1.3.5-Mesitylene	643·5	33·2	5·762	3687·8

8. In the case of a benzene ring with a side-chain (Series VI.) the value of C.T. × √C.P. will probably tend *to become constant when the possibility of isomerism has* become established. (*Cf.* methyl and ethyl benzenes with propyl and butyl benzenes. Series VI.).

The constants quoted in this paper are taken from standard text-books and from the *Journal of the Chemical Society*, 1893, *Abst.*, II., p. 446; 1903, *Abst.*, p. 545; 1902, *Abst.*, pp. 195 243, 303; 1906, *Trans.*, &c.

VOLUMETRIC ESTIMATION OF THE SULPHION.

By R. HOWDEN, B.Sc.

A RAPID method for the estimation of the SO_4 ion has long been a desideratum, and the following volumetric process may under certain conditions prove to be useful. The method is based on the decomposition of soluble alkaline sulphate by insoluble barium carbonate, generating alkaline carbonate which can be estimated by alkalimetric titration.

Let us assume that the solution we are dealing with contains sodium sulphate. Heavy metals or calcium can be precipitated by excess of sodium carbonate and filtered off. The solution must be made exactly neutral if not so to begin with, using methyl-orange as indicator. A few drops of phenol-phthalein solution and excess of pure precipitated $BaCO_3$ shaken up with water are added. Double decomposition takes place with the formation of $BaSO_4$ and Na_2CO_3, and the solution becomes red. Decinormal HCl is now run in from a burette till the red colour vanishes. This requires somewhat more than half the theoretical quantity of standard acid, and furnishes a fair approximation to the amount of sulphate present in the solution. To obtain a more exact result the insoluble barium salts are now filtered off, the filter washed, and the titration completed on the filtrate, using methyl-orange as indicator. If preferred an aliquot portion may be passed through the filter and titrated.

The preliminary addition of standard acid to the *unfiltered solution appears to be necessary in order that* the reaction may run its full course, but the addition of acid should not be continued beyond the discharge of the red colour, so as to avoid the danger of bringing Ba into solution as acid carbonate.

The method as above outlined does not claim to be more than a good approximation, as it is found on testing the solution after titration that small quantities of both Ba and SO_4 are present. These two sources of error are, however, compensatory, and the following results show that a very satisfactory degree of accuracy can be obtained:—

5 cc. of approximately N/10 K_2SO_4 required 4·9 cc. of N/10 HCl.
10 cc. of approximately N/10 K_2SO_4 required 9·8 cc. of N/10 HCl.
20 cc. of approximately N/10 K_2SO_4 required 19·6 cc. of N/10 HCl.

Gosforth, Newcastle-on-Tyne.

CHEMICAL TECHNOLOGY AT THE IMPERIAL COLLEGE OF SCIENCE.

IN order to meet adequately the prospective requirements of the post-war situation, it is proposed to reorganise the Department of Chemical Technology *so as to include the* following four principal sections:—

A. *Fuel Technology and Chemistry of Gases, with Refractory Materials.*

It is suggested that this group of subjects shall be *located in the existing Fuel Block,* considerably enlarged and extended so as to provide accommodation for the following subjects:—(*a*) General fuel technology, and the constitution of peats, lignites, and coals; (*b*) the carbonisation of coal and wood distillation; (*c*) the chemistry of coal tar, ammonia, and the manufacture of intermediate products from coal tar; (*d*) the chemistry of gases and technical gas catalysis, with special reference to the new developments in the manufacture of ammonia, nitric acid, sulphuric anhydride, &c., resulting from the war; (*e*) refractory materials, clays, earths, and sands, used in furnace construction and the manufacture of ceramics, glass, and cements; and (*f*) technical analysis connected with the foregoing.

The arrangements contemplated under (*e*) would include some provision for investigating the materials used in the manufacture of optical glass, which it is hoped will be a *useful adjunct to the new Department of Technical* Optics; those under (*b*) meet the need of an adequate provision being made in this country for the scientific study of wood distillation, &c., in the interests of India and the Empire generally; and those under (*a*) will provide for an extension of the investigations on lignites which have already been conducted during the war, in the interests of the Dominions.

B. *Chemical Engineering.*

This section will be provided with suitable drawing offices and laboratories for advanced study and investigations upon:—

(*a*) The materials and principles involved in the design, construction, and use of plant for general factory operations. (*b*) The design and construction of foundations, flues, chimneys, &c. (*c*) Factory economics and organisation.

The underlying idea of this section of the department's work is that students shall be trained in the working out of designs of commercial plant from their own notes and experimental work, including the drawing up of plans and specifications, and the organisation of factories in which the above-mentioned operations are carried out.

C. *Electro-Chemistry.*

This section will be developed so as to include broadly the principal applications of electricity to chemical industry, and *especially* to the many processes which are dependent upon the electrolytic or ionising actions of currents. These include, *inter alia*, the manufacture of caustic alkalis, chlorine, hypochlorites, &c.; "peroxidised" products such as persulphates, perchlorates, permanganates, &c.; also white lead, and such metals as sodium, magnesium, *aluminium, calcium, and electrolytic* "reduction" and "oxidation" of organic substances.

D. *Technology of Carbohydrates, Fats, Oils, and Rubber.*

The selection of the subjects to be included under this section has been largely influenced by two considerations, namely:—

(1) The already large provision (*a*) in Manchester, Leeds, and Huddersfield, for advanced study and research upon Dyes and Tinctorial Chemistry, as applied to the great textile industries of the country; (*b*) in Leeds and *in London in connection with the leather industries*; and (*c*) in Birmingham in respect of the fermentation in-

dustries; and (2) the lack of any really adequate provision in this country for the needs of equally important branches of industry which depend upon the extraction and refining of certain well-defined groups of natural (and chiefly vegetable) raw materials.

The technology of the following group of natural products has been selected because of their increasing economic importance, and of their close relationships with the work already developed in the Botany Department. It can scarcely be doubted that the study and investigation of their chemical properties, treatment, and uses will constitute an important link with the economic development of the vegetable resources of the Empire. The products in question are as follows:—(i.) Celluloses, sugars, starches, gums, dextrins, and resins; (ii.) animal and vegetable oils and fats, and the manufacture of glycerin, soap, and food products (*e.g.*, margarine) therefrom; (iii.) rubber, and similar materials.

The additional financial requirements for the developments outlined above are estimated at £100,000 for buildings and equipment, and not less than £10,000 a year for maintenance and working expenses.—*Journal of the Society of Chemical Industry*, xxxvii., No. 21.

THE SOCIETY OF BRITISH SCIENCE STUDENTS.

The principal object of the Society is to strengthen the relations between the younger students of science in this country by means of meetings, lectures, and publications, and by all other suitable measures. The Society will co-operate with other kindred associations tending to encourage a more intimate understanding between students of science in all its branches. It will endeavour to make arrangements regarding books, periodicals, and apparatus, and it is hoped that at some future date a journal will be instituted. Information will be collected by the Secretary and other officials of the Society, of importance to the science student, such as that relating to posts, scholarships, colleges, &c. The Society will endeavour to secure privileges for its members in regard to other societies, and will, as far as possible, safeguard the interests of the science student as a class. Students unfortunately placed in any way will be helped, and schemes will be considered for helping those of our members in the Forces whose studies have been retarded by the war. It is an essential part of the scheme that all sciences should be represented in the Society.

At a meeting held on July 15, in the library of the Chemical Department of the Northern Polytechnic Institute, London, by kind permission of the Principal, Dr. R. S. Clay, a temporary executive with the following composition was elected:—President, Lieut. Bennett, R.E.; Hon. Gen. Secretary, Mr. P. E. Owens; Hon. Treasurer, Mr. H. Nicol; Pte. Butler; a Lady Representative.

It was decided that an entrance fee of 3s. should be payable by each new member. All prospective members (including all those who have previously affirmed their intention of joining the Society) are therefore asked to forward this amount to the Hon. Sec., at the address below. This fee should be accompanied by a signed statement of desire to join the Society, and, on the Secretary's request, enough particulars should be given to show that the applicant is a genuine student of science. The monthly subscription will be definitely settled by the Executive, and will probably be about 1s. 6d. This sum will go towards the expense of carrying out the various schemes at present in view, to purchasing periodicals for circulation, founding a library, and, later, hiring a meeting room in London. A certificate of membership will be made out to each member. Students of all sciences and either sex are eligible for membership.

All enquiries should be addressed to the Hon. Secretary, P. E. Owens, 28, Jesse Terrace, Reading.

ORDERS OF MINISTRY OF MUNITIONS.

Sulphuric Acid.

The Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm Regulations, and of all other powers enabling him, hereby orders as follows:—

1. As on and from November 1, 1918, the maximum prices for Sulphuric Acid fixed by the Sulphuric Acid (Amendment of Prices) Order, 1918, shall cease to be operative, and such Order shall be deemed to be cancelled, but such cancellation shall not affect the operation of that Order up to October 31, 1918, nor the liability to any penalty or punishment in respect of any contravention or failure to comply with the Sulphuric Acid Order, 1917, as amended by the Sulphuric Acid (Amendment of Prices) Order, 1918, occurring prior to November 1, 1918, nor any proceeding or remedy in respect of such penalty or punishment.

2. As on and from November 1, 1918, the maximum prices for Sulphuric Acid specified in the schedule to this Order shall be deemed substituted for those specified in the schedule to this Sulphuric Acid Order, 1917, and such last-mentioned Order shall accordingly operate and have effect as though the prices specified in the schedule hereto had originally been fixed by the said Order as the maximum prices to be charged or received in payment by manufacturers of Sulphuric Acid or agents of such manufacturers for Sulphuric Acid supplied by or through them on or after November 1, 1918.

3. This Order may be cited as the Sulphuric Acid (Amendment of Prices) No. 2 Order, 1918, and as from November 1, 1918, the Sulphuric Acid Order, 1917, and this Order may be cited together as the Sulphuric Acid Orders, 1917-18.

(Note.—All applications in reference to this Order should be addressed to the Director of Acid Supplies, Ministry of Munitions of War, Department of Explosives Supply, Storey's Gate, Westminster, S.W. 1).

Schedule.

Maximum Prices for Sulphuric Acid.

1. Weak acid, *i.e.*, acid of all strengths up to and including 90 per cent H_2SO_4.

Class A. Arsenical acid. Max. price per ton, 88s. For acid of 140° Tw. at 60° F., with an increase or reduction of 6d. in respect of each complete degree Twaddell by which specific gravity is more or less than 140° Tw. at 60° F.

Class B. Non-arsenical or de-arsenicated acid. Max. price per ton, 105s. For acid of 140° Tw. at 60° F., with an increase or reduction of 7d. in respect of each complete degree Twaddell by which the specific gravity is more or less than 140° Tw. at 60° F.

2. Concentrated acid, *i.e.*, acid of all strengths over 90° per cent H_2SO_4.

Mono-hydrate (H_2SO_4). Content of acid. Per cent.	Per cent.	Maximum price per ton. Class C. Arsenical acid. £	s.	d.	Class D. De-arsenicated or non-arsenical acid. £	s.	d.
Over 90 and up to	91	5	19	6	7	5	3
" 91 "	92	6	6	0	7	12	3
" 92 "	93	6	12	6	7	19	3
" 93 "	93½	6	19	0	8	6	3
" 93½ "	94	7	2	3	8	9	9
" 94 "	94½	7	5	6	8	13	3
" 94½ "	95	7	8	9	8	16	9
" 95 "	95½	7	13	9	9	2	0
" 95½ "	96	7	18	9	9	7	6

Over 96 per cent in both classes, an addition of 1s. 2d. per ton for each complete one-tenth of 1 per cent of additional mono-hydrate.

Packages.

All the above maximum prices are for acid delivered into tank wagon, tank cart, or tank barge at maker's works.

When the acid maker supplies the railway tank wagons, he shall be entitled to make a further charge of not more than 5s. per ton for hire of such wagons, and also to charge demurrage on tank wagons detained at the purchaser's sidings for more than one clear day, exclusive of the days of arrival and despatch, at a rate not exceeding 6d. per ton capacity per day in respect of each clear day, after the first during which the same are so detained.

When the acid maker supplies the acid in his own drums he shall be entitled to make a further charge of not more than 10s. per ton for filling and hire of drums. When drums are supplied by the purchaser a charge of 2s. per ton may be made to cover the cost of filling.

When the acid is supplied in the acid maker's own carboys, he shall be entitled to make a further charge of £1 per ton for filling and hire of carboys. When carboys are supplied by the purchaser, a charge of 5s. per ton may be made by the acid maker to cover the cost of filling.

Extra Carriage.

In cases where a maker of sulphuric acid has, in order to supply his customers, to purchase supplies of acid from a third party, it will be permissible for him, in so far as this is a departure from his normal procedure, to charge to his customers any extra cost of carriage thereby incurred.

SHELLAC.

In reference to the Shellac Control Order, 1918, made by the Minister of Munitions, and dated March 12, 1918, the Minister of Munitions hereby orders as follows:—

1. As from the date hereof the said Order is hereby revoked.

2. Such revocation shall not affect the previous operation of the said Order or the validity of any action taken thereunder or the liability to any penalty or punishment in respect of any contravention or failure to comply with the said Order prior to such revocation, or any proceeding or remedy in respect of such penalty or punishment.

3. This Order may be cited as the Shellac Revocation Order, 1918.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, November 21, 1918.

Sir J. J. THOMSON, O.M., President, in the Chair.

THE following papers were read:—

"*The Influence of External Concentration on the Position of the Equilibrium attained in the Intake of Salts by Plant Cells.*" By W. STILES and F. KIDD, D.Sc.

The course of intake of salts by carrot and potato tissue has been followed by measuring the changes in electrical conductivity of the solution of salt presented to the tissue. Concentrations of each salt were employed ranging from 0·1 to 0·0002 normal.

In the case of copper sulphate exosmosis from the tissue exceeds absorption, and this is so with all concentrations of the salt. This is characteristic of toxic substances.

Carrot tissue absorbs the chlorides of potassium, sodium, and calcium in all concentrations employed. Absorption takes place at first at a rate approximately proportional to the external concentration, but this relation is not continued with time as the absorption progresses towards an equilibrium condition in which the ratio of internal to external concentration is not constant but varies with the concentration. This ratio of internal to external concentration we call the absorption ratio. It decreases with increasing concentration. With low external concentrations, *e.g.*, 0·0002 N and 0·002 N, it is many times unity; with higher concentrations, *e.g.*, 0·1 N, it is less than unity.

The relation between the final internal and external concentrations appears to be given by the adsorption equation $y = kc^m$, where y is the final internal and c the final external concentration, but the data presented are regarded as inadequate in themselves to justify the conclusion that absorption of salts by the cell is an adsorption process.

"*The Comparative Rate of Absorption of Various Salts by Plant Tissue.*" By W. STILES and F. KIDD, D.Sc.

The absorption of various chlorides, sulphates, nitrates, and potassium salts from solutions of 0·02 N concentration was measured by the electrical conductivity method employed in the investigation recorded in the previous paper.

Kations appear to be absorbed initially in the following order:—K [Ca, Na] Li [Mg, Zn] Al. The position of ions enclosed within brackets may have to be reversed. This initial order does not indicate, however, the extent to which the ions are absorbed when equilibrium is reached; the order is then K, Na, Li [Ca, Mg]. The chief difference between this order and the initial order is in the position of Ca, which is ultimately absorbed to only a slight extent compared with K and Na.

Anions are absorbed initially in the order SO_4, NO_3, Cl, which gives place later to the order NO_3, Cl, SO_4 on account of the comparatively slight extent to which the sulphate ion is absorbed. The difference between nitrate and chloride is slight, and no stress can be laid on it.

These results agree in general with those of Ruhland, Fitting, Pantanelli, and Troendle using different methods and different experimental material. These authors did not, however, distinguish between initial rates of absorption and the position of final equilibrium. The position of final equilibrium appears to be governed by some quite different property from that which determines the initial rate of intake.

"*Recherches Anatomo-Cliniques sur les Névromes l'Amputations Douloureux. Nouvelles Contributions à l'Etude de la Régénération Nerveuse et du Neurotropisme.*" By G. MARINESCO.

Ordinary Meeting, December 5, 1918.

Dr. J. W. L. GLAISHER, Vice-President, in the Chair.

THE following papers were read:—

"*Electric Potential Gradient and Atmospheric Opacity at Kew Observatory.*" By C. CHREE, Sc.D., F.R.S.

It has been the practice for many years at Kew Observatory at the ordinary hours of meteorological observation to record the most distant of a selected series of objects which is visible at the time. Separate notes are also made of the presence of mist or fog. Thus a large amount of information has accumulated as to the greater or less opacity of the atmosphere. The present paper utilises the data for a comparison of atmospheric opacity and the potential gradient of atmospheric electricity. It is found that even for the smallest amount of opacity which the observation scheme is able to disclose, the value of the potential gradient increases with the opacity. The effect of mist or fog on the potential gradients recorded in winter is large, and there being a large diurnal variation in the incidence of mist or fog, there is consequently a noteworthy influence on the character of the diurnal variation of potential gradient.

"*Value of the Secular Acceleration of the Mean Longitude of the Moon.*" By E. NEVILL, F.R.S.

It is shown that where the observed errors of the tabular

place of the moon are properly corrected for the observed errors in the values of the principal coefficients employed in Hansen's Lunar Tables, the residual errors are such as to show that the true value of the coefficient of the secular acceleration in the mean motion of the moon cannot differ sensibly from the value 6″·2 assigned to it by theory, so that it affords no evidence from observation of any tidal retardation in the rotation of the earth.

"*Investigations Dealing with the State of Aggregation. Part IV. The Flocculation of Colloids by Salts containing Univalent Organic Ions.*" By S. B. SCHRYVER and NITA E. SPEER.

The theories dealing with the mechanism of the action of salts in flocculating colloids is discussed. According to one theory the adsorption of the discharging ion of the flocculating salt is the predominant action. If this is the case, it might be expected that salts which cause the greatest lowering of the surface tension of water would exert the greatest flocculating action where water is the dispersion medium. A series of salts containing organic ions was chosen, of which the normal solutions exhibit a wide range of surface tensions, and their flocculating action on a number of colloids was investigated.

In general, no relationship was found to exist between this action and the surface tensions of the solutions. In one case, however (that of mastic), there was a marked parallelism. Attention is called to the fact that two classes of suspensoid colloids might exist. The first class comprises those colloids which owe their charge to an ion of the salt from which the colloid is prepared, as, for example, the chlorine ion attached to a ferric hydroxide sol prepared by the hydrolysis of ferric chloride. The second class includes colloids in which the charge is due to a dissociated labile ion belonging to the colloid proper, held electrostatically to a less labile ion, as, for example, the mastic colloid, when a hydrogen ion (of the carboxyl radicle) is held electrostatically to a large anion. It is proposed to designate colloids of the first class *exionic*, and those of the second class *endionic*.

"*A Study of the Forms assumed by Drops and Vortices of a Gelatinising Liquid in Various Coagulating Solutions.*" By EMIL HATSCHEK.

The paper describes a series of experiments in which drops of gelatin sol are allowed to fall into various solutions. Conditions can be so arranged that gelation takes place when any desired shape of the hanging drop or vortex thus produced has been attained. The result is permanent models of what are only transient forms when two liquids are employed, as in the experimental methods practised hitherto. If the solutions have a dehydrating effect on gelatin, a number of features not produced at all with liquids appear, such as radial ribs and membranes, or, generally speaking, cross-sections other than circular.

The conditions can further be varied by the use of solutions, or of salts added to the gelatin sol, which lead to the production of permeable or semi-permeable membranes on the gelatin drop. By these means a further range of forms can be obtained, such as by-concave discs of the shape of the human red blood corpuscle, hanging drops showing abnormal profiles and superficial segmentation, and vortex forms greatly modified by general shrinkage.

Many of the forms obtained in these experiments show a close resemblance to those of the simpler organisms, both as regards general outline and secondary features.

PHYSICAL SOCIETY.

Ordinary Meeting, November 8, 1918.

Prof. C. H. LEES, F.R.S., in the Chair.

A PAPER on "*Low Voltage Arcs in Metallic Vapours*" was read by Prof. J. C. MCLENNAN, F.R.S.

The paper describes experiments by Messrs. Hamer and Kemp, students of the author's, at Toronto University. The experiments show that increasing the temperature of the incandescent cathode lowers the voltage necessary to produce arcs in the vapours of mercury, zinc, and cadmium. With limed platinum cathodes arcing voltages were not obtained as low as with incandescent tungsten filaments. With mercury it was found possible to strike arcs with voltages as low as 4·75 volts, and to maintain them at 2·84 volts. Corresponding figures for cadmium were 5 and 2 volts. To obtain these very low arcing voltages it was necessary to use intensely hot cathodes and a copious supply of highly heated metallic vapour. With moderately heated incandescent cathodes and a moderate supply of metallic vapour the arcing voltages were given by the Quantum relation $V = h \times (1 \cdot 5, S)/e$, where $1 \cdot 5, S$ is the frequency of the shortest wave-length in the $v = 1 \cdot 5\ S - mP$ series.

DISCUSSION.

Dr. H. S. ALLEN, referring to the production of single-line spectra, suggested that possibly the non-appearance of other lines of the series might be due to the fact that in the case of these spectra the plate was necessarily much under-exposed, and one was working on the initial slowly sloping part of the exposure-density curve. A very faint line which produced no appreciable photographic effect under these circumstances might, nevertheless, do so if the plate were given a preliminary exposure sufficient to bring its initial density on to the steep part of the curve.

Dr. D. OWEN said that the experiments undoubtedly showed that these arcs could be struck with voltages less than that given by the Quantum relation. The result implied that the additional energy came from a source other than the battery. The hot cathode was such a source, and the question was how did the energy become added to that of the battery so as to produce the required total E.M.F.?

Dr. W. WILSON suggested that the investigations of Richardson and his pupils on the work necessary for the liberation of an electron from hot bodies, such as tungsten, supplied the necessary data from which to calculate, on the assumption of a Maxwellian distribution, what proportion of the positive corpuscles had sufficient energy to liberate an electron on impact with the cathode.

Dr. BEATTIE asked what was the magnitude of the current in these arcs. He presumed there was a marked increase when the arc was struck.

The PRESIDENT said he was much interested in the explanation of the production of the arc by the impact of the positive electrons on the cathode. This appeared to involve that the area of the electrode would have an effect on the striking voltage. Had this point been investigated?

Mr. J. GUILD asked what was Prof. McLennan's explanation of the continuous spectrum accompanying the line spectrum in the case of the brilliant arcs.

Prof. MCLENNAN, in reply, said Dr. Allen's suggestion was new to him, and ought certainly to be tried. With regard to the conversion of the thermal energy of the filament, there might be chemical action of some sort involved. In reply to Dr. Beattie, the current did increase when the arc was struck. Speaking from memory, its magnitude was of the milliampere order. These arcs could be very intense—possibly 50 c.p.

A paper on "*Relativity and Gravitation*" was read by Dr. W. WILSON.

The motion of a particle in a gravitational field is treated from the point of view of the general theory of relativity. It is shown that the equations of motion of the particle can be expressed in the following Hamiltonian form:—

$$\frac{dp_s}{d\tau} = -\frac{\partial H}{\partial x_s},$$

$$\frac{dx_s}{d\tau} = \frac{\partial H}{\partial p_s},$$

where p_s is the s component of the covariant 4-vector

momentum, x_s the corresponding positional co-ordinate, and τ the Minkowskian "Eigenzeit." A short outline of the Minkowskian Theory of Relativity is included in the paper.

DISCUSSION.

Dr. H. S. ALLEN congratulated the author in expressing Einstein's theory in such a comparatively simple way.

Mr. T. SMITH asked what was the physical significance of the quantity H appearing in the equations.

The PRESIDENT asked what physical meaning would be attached to the product $dx_s\ dx_t$ when s and t were different.

Dr. WILSON, in reply, said that the quantity H had the dimensions of energy, and occupied a position in the 4-dimensional space-time manifold, similar to that of the Hamiltonian energy function in classical dynamics. He suggested the possibility that the s component of the co-variant 4-vector momentum p_s of the electron may be equal to eA_s, where A_s is the 4 vector potential in the neighbourhood of the electron and e is its charge. He could not, without taking up a great deal of time, explain the meaning of the terms $g_{st}\ dx_s\ dx_t$, $t=/=s$, in the expression for ds^2.

An Exhibition of some experiments on Colour Blindness was given by Mr. C. R. GIBSON, F.R.S.E.

The apparatus consisted of a lantern to produce a bright beam of white light and a coloured glass which could be slipped in front of it, so as to cut out all the red rays. Various samples of coloured cloths and ribbons arranged in pairs, while quite dissimilar when viewed by the white light appeared perfect matches with the screen interposed, the conditions then being similar to those in the case of a red blind person. He had found in experimenting with wools by this method that many coloured wools were unsuitable for the purpose on account of fluorescence. Thus although no red light fell on them from the apparatus, there was plenty of red in the light reflected by the wools. In these cases, in order to see what the colours would appear to the red blind man, it was necessary to have the filter between the wool and the eye, and not simply between the source of light and the wool.

Mr. C. C. PATERSON mentioned that in the case of signal lamps it was possible to tell red from green, quite apart from their colour, by looking at them indirectly. A green light got brighter off the line of vision, while a red light got fainter.

Mr. J. GUILD asked what screen was employed.

Mr. GIBSON said that any screen which cut out the red was suitable. He had tried gelatin dyed with the Sanger-Sheppard minus red. This was good enough for visual work, but not dense enough for the lantern. What he used was practically the ordinary "signal green" glass.

CHEMICAL SOCIETY.

Ordinary Meeting, November 7, 1918.

Prof. W. J. POPE, C.B.E., F.R.S., President, in the Chair.

THE PRESIDENT announced that the Society had lost, through death, the following Fellows:—Edward Frank Harrison (died on Service), James Bayne, Joseph John Bowley, Harry Broadbent, William Edward Callister, William Adam Dixon, Charles Thomas Foreman, Charles James Pemeller Fuller, David Smith Jardin, Sydney Lupton, Edward Matthey, Elias Mendoza, Alfred Senier, Walter Dalrymple Severn, John William Shepherd, Henry Charles Stephens, Christopher Wilson.

The Council desires to direct the attention of Fellows to the Army Education Scheme which has been prepared by the War Office. Under this scheme, an appeal is made for voluntary lecturers who would be willing to deliver occasional lectures to the troops in the United Kingdom, France, or Italy. In accordance with the scheme, the lecturers will not receive fees, but all expenses will be defrayed. Fellows who contemplate taking part in the scheme are requested to communicate with the Assistant Secretary, from whom further particulars can be obtained.

Messrs. W. R. Grist, F. W. Fitzgerald, A. Z. Molteni, R. L. T. Clarkson, and W. J. Lund were formally admitted as Fellows of the Chemical Society.

Certificates were read for the first time in favour of Lauchlan Henry Pyke Acland, B.A., Island View, Barton-on-Sea, Hants; Valentine George Anderson, 31, Victoria Avenue, Canterbury, Victoria, Australia; William Learmouth Baillie, 70, Hampton Road, Clifton, Bristol; Ernest George Balls, B.Sc., Orford House, Wellington Road, Wanstead, E. 11; Percy Barrs, 33, Lancaster Park, Richmond Hill, Richmond, Surrey; William Andrew Stewart Blaine, B.Sc., Ardbana Crescent, Coleraine; John Harold Bright, 157, Greenvale Road, Eltham, S.E. 9; Hubert Thomas Stanley Britton, B.Sc., Lynn Dene, Court Road, Kingswood, Bristol; Charles Daniel Buckley, 52, Gilda Brook Road, Eccles; Jules Cofman-Nicoresti, 15, Speenham Road, S.W. 9; Maurice Copisarow, M.Sc., The University, Manchester; Cyril Mutton Croft, 37, Rusholme Road, Putney, S.W. 15; Herbert Hector Donaldson, 15, Ash Leigh, Anfield, Liverpool; George Zephirin Dupain, "Symington," Parramatta Road, Ashfield, Sydney, Australia; Herbert John Evans, B.Sc., 7, Market Street, Haverfordwest; James Foster, 59, Elizabeth Street, North Woolwich, E. 16; Alfred Edwin Gates, 32, Conway Road, Luton; Herbert William Gepp, Hobart, Tasmania; Geoffrey Gladding, M.Sc., 4, Heaton Road, Heaton Norris, Stockport; George Grant, "Tinniver," Balmoral Avenue, Cathcart, Glasgow; John Russell Green, B.Sc., 2, Belmont Park, Lee, S.E. 13; William Duthie Haigh, B.A., B.Sc., 15, Cavendish Avenue, Church End, Finchley, N.; Harry Hepworth, M.Sc., Nobel's Explosives Co., Stevenston; Herbert Leslie Howard, 44, Disraeli Road, Forest Gate, E. 7; William Claude Jago, 17, Wilbury Avenue, Hove, B.O., Brighton; Cosmo Johns, Burngrove, Pittsmoor Road, Sheffield; Clifford William Judd, B.Sc., 4, Maytborne, Ardrossan Road, Saltcoats, B.O., Ayrshire; Frederick John Kettel, 47, Limes Road, Beckenham, Kent; Thomas Kilby, 1, Westfield Road, Toller Lane, Bradford; Norman Victor Sydney Knibbs, B.Sc., The Hostel, Langwith, Mansfield; Ernest Alfred Littlewood, 12, Brookfield Road, Crumpsall, Manchester; Shih Chen Loo, 70, High Lane, Chorlton-cum-Hardy, Manchester; John Armour McKerrow, M.A., B.Sc., 2, Kymer Villas, Kidwelly, Carmarthenshire; Charles Stewart Maries, B.Sc., Eggesford Cottage, Queens Road, Aldershot; Norman Lewis Matthews, 45, Tyrwhitt Road, Brockley, S.E. 4; Robert Alfred Moore, B.Sc., 9, Coniston Avenue, West Jesmond, Newcastle-on-Tyne; William Newton, Station Road, Wootton Bassett, Swindon; Douglas Norbury, Lyndene, Lansdowne Road, West Didsbury, Manchester; Edwin Hart Nurse, B.Sc., "Southwold," Lewis Road, Sutton, Surrey; Mehtab Singh Obroi, B.Sc., Gordon College, Rawal Pindi, India; Leslie Henry Parker, M.A., D.Sc., "The Chestnuts," Church Road, Leatherhead; John Paterson, 1, Rowallan Gardens, Glasgow; Wilfred Stanley Pheasey, Second Corps, B.E.F.; Alexander Park Porter, 157, Greenvale Road, Eltham, S.E. 9; Joseph Francis Pratt, 77, Hanbury Road, Pontnewynydd, Pontypool; Ralph John Pugh, 99, Londsdale Road, Barnes, S.W. 13; George Thomson Purves, "Thirlestane," Chryston, Glasgow; Dudley Ridge, 7, College Place, Brighton; Frederick Maurice Rowe, M.Sc., 5, Woodbine Terrace, Latchford, Warrington; Walter Salmon, 17, The Grove, Eccles; Monte Ambrose Shenton, 15, Cedar Avenue, Weaste, Manchester; William Ramsay Sibbald, 5, Manor Road, Hoylake, Birkenhead; George Smith, M.Sc., 33, Queen Street, Great Harwood, Blackburn; Thomas William Southron, 32, Casseldon Road, Harlesden, N.W. 10; Joseph Tavroges, B.Sc., 36, Grafton Street, Mile End Road, E. 1; William Henry Tomlinson,

B.Sc., Law Street, Turnpike, Waterfoot, Manchester; Walter Towse, Woodland Villa, Gladstonbury, Somerset; Henry Marshall Webb, B.Sc., 63, Lancaster Gate, W. 2; Percy William Weston, 59, Grafton Street, Manchester; Sidney Edward Whitehead, B.Sc.Eng., 92, Bristol Street, Birmingham; Charles Williams, B.Sc., 45, Oakington Manor Drive, Wembley, Middlesex; George Adamson Pemberton Wright, 36, Apsley Road, Clifton, Bristol.

The following Certificates have been authorised by the Council under By-law I. (3) for presentation to ballot:—Bhaktabatar Banerjee, M.Sc., 26, Mogul Street, Rangoon, Burma, India; Amulya Chandra Bose, B.Sc., Sakchi, via Kalimati, B.N. Rly., India; Louis Pierre Bosman, University of Capetown, Capetown, S. Africa; Tarak Prosad Ghose, B.Sc., Dehra Dun, United Provinces, India.

The following papers were read:—

"The Dilution Limits of Inflammability of Gaseous Mixtures. Part III. The Lower Limits of some Mixed Inflammable Gases with Air. Part IV. The Upper Limits of some Gases, Singly and Mixed, in Air." By H. F. Coward, C. W. Carpenter, and W. Payman.

"The *n*-Butylarylamines. Part I. The Action of *n*-Butylchloride on *o*- and *p*-Toluidines." By J. Reilly and W. J. Hickinbottom.

"The *n*-Butylarylamines. Part II. The Nitration Products of *n*-Butyl-*p*-toluidine." By J. Reilly and W. J. Hickinbottom.

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS.

Ordinary Meeting, December 5, 1918.

Dr. Samuel Rideal, President, in the Chair.

A certificate was read for the first time in favour of Mr. Cecil William Wood.

Certificates were read for the second time in favour of Messrs. Robert Howson Picard, D.Sc., Ph.D., F.I.C.; Lionel Guy Radcliffe, M.Sc., F.I.C.; James Smith; Frank Edwin Weston, B.Sc.; John Clare Newlands Eastick, A.I.C.; S. H. Blichfeldt.

The following papers were read:—

"*Recorder for Estimating Carbon Monoxide in Inflammable Gases.*" By Eric K. Rideal, M.B.E., M.A., Ph.D., and H. S. Taylor, D.Sc. The instrument described has been devised for the purpose of determining the purity of the hydrogen used in ammonia synthesis, and is of the continuous recording type. The method employed is to pass the gas through a special oxidising chamber in which the carbon monoxide is catalytically and preferentially oxidised to carbon dioxide by means of a special supply of oxygen. The oxidised gases are brought into contact with a constant stream of a standard solution of lime water, and the carbon dioxide formed recorded automatically by changes in the conductivity of the solution of lime water.

"*The Estimation of Phenacetin and other Para-aminophenol Derivatives by Hypochlorous Acid.*" By A. D. Powell. The author reviews the defects of methods hitherto in use for estimating substituted phenetidin compounds, and proposes one based on the action between sodium hypochlorite and an acid solution of para-aminophenol. This method is described in detail, and is shown to be applicable to the estimation of phenacetin in admixture with such substances as caffeine citrate, salol, and acetanilide, and also to other *p*-phenetidin or *p*-aminophenol derivatives used in medicine, as well as developers in photography. Incidentally the estimation enables the author to distinguish between metol and metol substitutes.

"*Effect of Morphine Concentration on the B.P. Method of Morphine Estimation.*" By Harold E. Annett, B.Sc., F.I.C., and Hardayal Singh, B.Sc. The authors have carried out investigations which show that the B.P. method, originally devised for the analysis of opium containing about 10 per cent of morphine, will, when suitably modified, give satisfactory results with smaller weights of opium down to one quarter that suggested in the Pharmacopœia.

INSTITUTE OF CHEMISTRY.

Suggested Government Chemical Service.—The Council of the Institute of Chemistry desire to direct the attention of His Majesty's Government to the increasing and vital importance of chemical science in affairs of the State.

The Institute, which has now been in existence for over forty years, is entrusted by Royal Charter with the duty of maintaining the status of the profession of chemistry, by prescribing courses of training for students of chemistry, by conducting examinations, and by the registration of persons found competent to practise.

During the War, moreover, the Institute of Chemistry has been one of the chief agents for mobilising the chemists of the country both for technical service with the Forces and in the production of war material of every description.

The Council submit the opinion that the time is opportune for taking steps to secure for the profession of chemistry a position corresponding to that occupied by other learned professions, and they feel that much would be accomplished towards the attainment of that aim if, in the first place, adequate and uniform conditions of appointment were accorded to chemists directly engaged in the service of the State.

The necessity for a definitely organised Chemical Service (both in peace and war) for all purposes of the State on which the science of chemistry has a bearing has long been recognised in the chemical profession, and representations have been made from time to time to ministers of State, Government Commissions, and other public authorities. As an example, it may be mentioned that, as the result of representations made by the Institute, the qualifications for appointment of public analysts under the Sale of Food and Drugs Acts have been determined by Regulations framed by the Local Government Boards for England and Wales, Scotland, and Ireland, under which the country has undoubtedly secured the services of a body of chemists highly qualified in that branch of work.

It may be pointed out also that the Department of the Government Chemist has been organised under a separate Treasury vote. Other departmental chemical establishments, however, have not been brought into line, and it does not appear that the position of chemists in the Government service generally is sufficiently understood and appreciated to obtain for them that measure of recognition which should be accorded to professional men of this type in the interests of the safety and well-being of the State.

The Council of the Institute regard it as a first principle that the Government should take steps to remove the confusion (existing in this but in no other country) which arises from the use of the title "chemist" by those who practise pharmacy.

The Government have already, in effect, recognised the true meaning of the designation "chemist" by applying this title to the "Government Chemist," the "War Department Chemist," and the "Admiralty Chemist," who are not pharmacists. The Council feel that in the Government service the title "chemist" should be included in the designation applied to all properly qualified chemists, and that it should not be used in the case of any other appointments.

(The expression "properly qualified" in this connectoin should be taken to mean chemists who have attained a

standard of competency at least equivalent to that required for the Associateship of the Institute under the Regulations adopted in accordance with the Charter. Briefly the standard adopted for the Associateship of the Institute is that of a university degree with first or second class honours in chemistry, including systematic training in physics and allied sciences. This involves a technical training extending over at least four years, and one comparable, therefore, with the training required for other professions).

The Civil Service includes chemists engaged in research, in analysis, and in technological work, as well as those employed in educational work. This memorandum relates chiefly to the first three branches.

Only persons possessing recognised qualifications should be eligible for appointment as chemists in the Government Chemical Service. Such appointments should be rendered attractive to those who have reached the required standard of efficiency. There should be no confusion between these chemists and their unqualified assistants.

The Council suggest—

1. That, as candidates should be required to produce evidence of qualification, the appointment of chemists should be based on a system of selection by properly constituted authority, and not by examination or nomination.

2. That the names of approved candidates should be placed on a short list, from which the heads of the respective Government chemical establishments would themselves make the final selection.

3. That persons appointed as chemists should be graded as civil servants in the Higher Division, preferably as members of a professional division, if such be at any time constituted, with status, emoluments, and pension comparable with those of the members of other technical and learned professions employed by the Government.

(It is further suggested for consideration that pensions should follow the lines of the insurance scheme of the federated universities, which has been adopted by the National Physical Laboratory).

4. That, dependent on satisfactory service, the system should provide for certainty of promotion (with corresponding advance in emoluments) up to a definite rank, independent of the occurrence of vacancies.

(NOTE.—This is a necessary condition if men of the best type are to be obtained. A chemist should be constantly increasing in efficiency, and this should be recognised by providing for certainty of promotion as suggested, not necessarily to the highest rank, but to one securing an adequate salary to a married man, say, to that of Principal Assistant Chemist in the scale outlined in (5) below).

5. That suitable titles should be allotted to the different ranks of the Government Chemical Service, in order of seniority as under, the rank held by the head chemist in any establishment being determined by the size of the establishment and by the nature of the work carried out:—Chief Chemist, with, in certain cases, a special departmental title; Deputy Chief Chemist; Superintending Chemist; Principal Assistant Chemist; Senior Assistant Chemist; Junior Assistant Chemist.

6. That definite salaries and increments should be prescribed for all ranks of the Government Chemical Service.

7. That the secondary staff, to whom the title chemist would not be applicable, should be classified as under:—

(*a*) Chemical Assistants (Senior and Junior), who should be men of good education, but without full professional qualification. (On obtaining the latter they would become eligible for appointment as chemists and would acquire the status necessary for presenting themselves to the board of selection referred to above).

(*b*) Laboratory Assistants (Chief, Senior, and Junior), who should be capable of performing simple chemical operations, assisting the chemists in the routine or mechanical parts of their work, fitting up apparatus, &c.

(*c*) Laboratory Attendants (Senior and Junior), who would do the ordinary work of caretaking, cleaning of the laboratory and apparatus, &c., with prospects of promotion to Laboratory Assistant.

The Council believe that, apart from the direct advantage to the State which would accrue from such an organisation, the recognition thus given to chemists by His Majesty's Government would raise the status of the profession of chemistry and incidentally contribute to the advancement of chemical science.—By order of the Council,

RICHARD B. PILCHER, Registrar and Secretary.

NOTICES OF BOOKS.

A Complete Course of Volumetric Analysis. By WILLIAM T. BOONE, B.A., B.Sc. London, Glasgow, and Bombay: Blackie and Son, Ltd. 1918. Pp. viii + 164. Price 3s. 6d. net.

THIS work provides a complete course of volumetric work for beginners assuming no previous knowledge of analysis. The earlier experiments are very fully and accurately described and the directions are particularly clear and complete. Throughout the book great stress is laid upon accuracy, and the student is urged to pay special attention to carefulness in manipulation and detail. The common expedient of introducing questions bearing upon the work at intervals throughout the text is adopted, the answers being given at the end of the book. The hand of the experienced teacher is apparent on every page, and the students who use the book will find themselves continually stimulated to thought and deductive reasoning while acquiring a well-founded knowledge of the principles and methods of volumetric work. While no particular novelty is to be noted either in the scope or details of the book it may be classed as a satisfactory specimen of a text-book for the use of the higher forms in schools and junior college classes.

A Short Hand-book of Oil Analysis. By AUGUSTUS H. GILL, S.B., Ph.D. Revised Eighth Edition. Philadelphia and London: J. B. Lippincott Company. 1918. Pp. 209. Price 15s. 6d. net.

THE changes made in the eighth edition of this handbook include a general revision of methods and data, as well as a description of some new apparatus, such as the MacMichael viscosimeter. The usual methods of analysis of edible and hardened fats and oils are described, and some additional tests for lubricating oils are given. The book is a useful introduction to larger works, and the carefully described details of processes and apparatus make it a very suitable book for students who are beginning oil analysis. The technology of mineral as well as animal and vegetable oils is fully treated, and systematically arranged information is given as to the sources and preparation, the chemical composition, adulterants and uses of all the commonly occuring oils. One chapter is devoted to general considerations regarding lubricants and to the method of examination of an unknown oil.

Annual Chemical Directory of the United States. Second Edition. Baltimore: Williams and Wilkins Company. 1918. Pp. 534. Price 5.00 dols. net, post paid.

THE great increase in size of the 1918 over the 1917 edition of this Directory clearly indicates the growth of American chemical industry, and as all the information given has been obtained from direct sources there is every probability of its being entirely reliable. The arrangement of the Directory is perhaps exceptional, and is certainly remarkably convenient. Chemical products of all kinds are first listed alphabetically, and under each heading names of manufacturers, retailers, dealers, agents, and

importers are grouped more or less geographically. These comprehensive lists are followed in Chapter II. by an alphabetical arrangement of all the names of manufacturers and dealers. All kinds of chemical and engineering apparatus and equipment are similarly treated in the next two chapters, and then follow alphabetical lists of analytical and consulting chemists, laboratories, technical and scientific societies and publications. These lists include foreign as well as American names, and in every way the preparation of the Directory appears to have been most efficiently carried out.

MISCELLANEOUS.

Announcement.—Mr. Clifford C. Paterson desires to announce that he is terminating his appointment at the National Physical Laboratory, Teddington, and is joining the General Electric Co., Ltd., as Director of Research Laboratories as from January 1, 1919. Pending the erection of the necessary laboratory buildings, the temporary offices and address of the Research Laboratories of the General Electric Co., Ltd., will be at the Osram Robertson Lamp Works, Hammersmith.

Royal Institution.—A Christmas Course of Juvenile Lectures will be delivered by Prof. D'Arcy Thompson on "The Fish of the Sea," beginning on December 31 at 3 o'clock. Courses of Lectures will be given before Easter by Prof. Spenser Wilkinson on "Lessons of the War"; Prof. MacGregor-Morris on "Study of Electric Arcs and their Applications"; Captain G. P. Thomson on "The Development of Aeroplanes in the Great War," and "The Dynamics of Flying"; Prof. Hele-Shaw on "Clutches"; Prof. Arthur Keith on "British Ethnology—The People of Scotland"; Prof. Norman Collie on "Chemical Studies of Oriental Porcelain"; Dr. William Wilson on "The Movements of the Sun, Earth, and Moon" (illustrated by a new astronomical model); Prof. H. M. Lefroy on "Insect Enemies of our Food Supplies," and "How Silk is Grown and Made"; Mr. Charles Aitken (Director of National Gallery of British Arts) on "Rossetti, Whistler, and Sargent"; Prof. C. H. Lees on "Fire Cracks and the Forces producing them"; Prof. A. Findlay on "Colloidal Matter and its Properties"; Rev. Canon Hannay on "The Irish Literary Renaissance"; Prof. H. P. Allen (Director of the Royal College of Music) on "The Works of J. S. Bach" with musical illustrations by members of the Bach Choir); Hon. J. W. Fortescue on "The Empire's Share in England's Wars"; and Prof. Sir J. J. Thomson (Master of Trinity) on "Spectrum Analysis and its Application to Atomic Structure." The Friday Discourses will begin on January 17 when Prof. Sir James Dewar will give a lecture on "Liquid Air and the War"; and discourses will also be delivered by the following gentlemen:—Temp. Lieut.-Col. A. Balfour, Prof. H. H. Turner, Prof. J. G. Adami, Prof. C. G. Knott, Mr. A. T. Hare, Prof. J. A. McClelland, Prof. H. C. H. Carpenter, Prof. Arthur Keith, Prof. W. W. Watts, Sir John H. A. Macdonald, and Prof. Sir J. J. Thomson.

NOTES AND QUERIES.

New Industries.—In our last issue the first query should read:—Mr. James Crerar, 107, Clarkston Road, Cathcart, Glasgow, desires information re Fixation of Atmospheric Nitrogen (Gilmour's Patent)."——Second Lieut. J. R. Micklethwait, R.A. Mess, No. 14, Reserve Brigade, R.F.A., Newcastle-on-Tyne, desires information on the Synthetic Production of Ammonia and its subsequent transformation into nitric acid for agricultural fertilisers, &c.——50555 Sapper E. Dunne, No. 1 Company, Malarial Con. Camp, Larkhill, Salisbury Plain, desires information re the manufacture of Oriel Paints and the Reduction and Refining of Copper, Iron, Sulphur, and Lead Ores.——Mr. Andrew Danks, Mossview, Netherburn, Lanarkshire, is in possession of special facilities and is considering establishing a factory for the manufacture of Calcium Carbide, and would be glad of any information regarding the same.——Mr. W. C. Stewart, 101, Grove Street, Glasgow, desires information re the manufacture of Matches and the best lighting composition to put on the heads; also the best sources of supply of same.

To comply with Regulation 8 (b) of the Defence of the Realm Act, advertisements from firms whose business consists wholly or mainly in Engineering, Shipbuilding, or the production of Munitions of War, or of substances required for the production thereof, must include the words "No person resident more than ten miles away or already engaged on Government work will be engaged."

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